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Belgian Currency and Exports

The decision of the Belgian Government to reduce still further the gold value of her currency has created a certain amount of alarm in this country, especially amongst the manufacturers of iron and steel. It is realised that this action will enable Belgium to compete in the export markets of the world, possibly to the detriment of British trade. The existence of the steel cartel has been threatened as it has been so often before, but somehow it invariably manages to continue. On this occasion Britain has accorded an annual import quota of 643,000 tons, which should go far towards the stabilisation of prices on the international market. So far as the foundry industry is concerned, it will be remembered that when Britain was a free market, the Belgians had a profitable business in the supply of automobile cylinders, and competition may arise again, but with this difference—the British foundry industry has made such very great technical progress since the time when the automobile industry was protected, that the motor manufacturers should have no excuse other than price considerations for changing their existing sources of supply.

Another direction which may prove more serious is the Eastern market for rice bowls, but here they will have to meet, *inter alia*, Indian competition. According to the experts, the fullest blast of the competition should be felt almost immediately, but because Belgium will have to pay full price for her imported raw materials, the advantage cited will gradually decrease.

An important repercussion is expected on the copper market, as the Belgian Congo material may be used to attract foreign currency to Belgium, and the international prices may be depressed. The gravest danger, of course, is whether Belgium's action may break up the Gold Bloc. She is centrally situated amongst the Gold Bloc countries and it is as well to remember that nine years ago she reduced the gold value of the franc to one-seventh of its former value, and that she exports largely to these countries. Unlike Britain, which because of her great buying as well as her great selling capacity can force a large section of the international market to accommodate itself to sterling conditions, Belgium must take, when buying, international prices as she finds them. Thus, so far as the foundry industry is concerned, we expect some early competition for castings which will diminish in intensity with time, and a depressing effect on the copper market, unless the race for armaments can nullify this.

Reflections on the Welding Symposium.—I

The symposium on welding is now very largely over, and a mass of material has been presented and discussed as far as time available permitted. Those contributions of direct interest to the founder and concerning the welding of iron and steel castings for repair or fabrication we shall publish in our columns. We wish, however, to emphasise one or two points raised in other Papers, and which affect the relationship between castings and weldings, and in particular their competitive position.

Perhaps it should first of all be borne in mind that the various classification societies and insurance companies in this country have hitherto adopted a very sound attitude to welded construction, and there is no need to feel that its adoption is in advance of its technical merits. Time may, indeed, show that it does not fulfil the hopes entertained of it, for example, under vibrating stress, but that would be in spite of regulations governing its application. Then, again, the quality of individual jobs is greatly affected by workmanship and technique, a point which recurs at intervals throughout the Papers.

Those interested in weldings as opposed to castings may be divided into three categories. Those firms who are engaged in engineering production, but do not have a foundry, may have a natural inclination towards the use of weldings they can make for themselves. The second comprises engineering firms able to make and use both types of product and able to ascertain very fully their relative advantages and disadvantages. The third comprises foundries making for the trade and who, lacking facilities for welding, may feel that their product may be prejudiced by the progress of welding. A most interesting Paper from a firm in the second group is that of Mr. E. C. Davies, which gives an admirable survey of the various factors which influence the decision in favour of the one or the other type of product. A similar approach is given in the Paper by Mr. Hawkins and Mr. Donkin, which includes details of relative weights and costs of weldings and iron castings for given jobs, and also of weldings and steel castings. These suggest that while weldings offer a saving in weight and cost over cast steel, the difference is much less appreciable for cast iron. The conclusions are bound to stimulate the founding industry to strain every nerve, technically, scientifically and commercially, to ensure that the competition is with modern cast iron and not the material so frequently taken as typical of cast iron by many engineers.

XUM

Henry Wiggin & Company, Limited

ONE HUNDRED YEARS OF PROGRESS

A veterinary surgeon and the son of a woollen draper were the first founders of the firm which is now known as Henry Wiggin & Company, Limited. The former, Charles Askin, had noted some indifferent specimens of German silver while travelling in Europe and, having a taste for scientific experiment, he returned home determined to produce a better product. He and Brooke Evans, who controlled the commercial side of the business, began in a modest way in George Street Parade, Birmingham, under a sign which read "Nickel Refiners and German Silver Manufacturers." From this humble beginning has grown one of the largest and best-equipped rolling mills in Europe for nickel alloys, Henry Wiggin & Company, Limited, now at Wiggin Street, Birmingham.

A Romantic Discovery

The first raw material which Askin used for obtaining his nickel was a nickel-speiss residue which he obtained from the Pottery district of Staffordshire. There was very soon a shortage of this raw material and the new firm was faced with serious difficulties as a result. Askin obtained some arsenical nickel-cobalt ore from the Carpathians, but he at first found it impossible to separate the nickel from the cobalt. There then occurred one of those fortunate accidents which have so often changed the course of scientific history. It was suggested to him by White Benson, the father of the late Archbishop Benson, that it might be possible to precipitate the metals from their ore by the addition of bleaching powder. Both men arranged to try the experiment separately on the same day. Benson had access to whatever bleaching powder he required, but his attempt was marked by failure. Askin, on the other hand, found to his annoyance that he had been supplied with only half the quantity he had asked for. Exasperated, he flung this amount into his retort and was unexpectedly rewarded by obtaining a precipitate of cobalt sesquioxide. The green solution above it contained the nickel and it proved easy to precipitate this with ordinary lime. This fortunate chance set the firm on a sound footing. Not only was this method technically and financially successful in providing refined nickel of high quality, but it revolutionised pottery ornamentation in also providing pure cobalt. Hitherto only impure cobalt had been available and the blues so produced were dull and greyish. With the oxide of cobalt obtained from Askin's experiment new clear colours became available, ranging from pale grey to deep purple, and famous pottery firms, including that at Sevres, obtained their blues from Birmingham.

Paying His Way

Nine years later a young man, Henry Wiggin, also intended for a woollen draper, forsook his apprenticeship to that trade, and at the age of 18 entered the business of nickel refining under Charles Askin and Brooke Evans. He entered the firm at a particularly favourable time. Among other things, Elkington's discovery of the possibility of commercial electroplating was increasing the demand for "German," now "nickel" silver, and it was decided to remove the refining side of the business to larger premises. On Birmingham Heath, which is now Wiggin Street, there were buildings occupied by Brandeis, a competitor, who, by copying the process of Askin and Evans, had hoped to profit. He was entirely unsuccessful in his venture, but after his business had been purchased by Askin and Evans, young Wiggin recovered the equivalent of the entire purchase price from the discarded slag left there by Brandeis.

Henry Wiggin

In 1847, just as Askin was about to retire, he died in Gusdal, Norway, whither he had gone to make inquiries concerning nickel-ore deposits in that district. In his Will he remembered Henry Wiggin favourably, and the following year the young man, at the age of 24, was taken into partnership by Brooke Evans. Fourteen years later Evans died, and within a year or two Henry Wiggin was in sole charge of the business. He was a man with varied interests and took a great part in the public life of the time. Becoming a member of the Birmingham Council, he was elected Mayor within three years. In 1880 he became a Member of Parliament and sat for 12 years. His hobby was agriculture, and he owned Lea End Farm, near Avechurch. A story is told that at harvest time he would send his workmen from Wiggin Street to his farm, saying they were far more use in helping to get the harvest in than refining nickel. In 1901 Sir Henry Wiggin, Bt., as he subsequently became, celebrated, with Lady Wiggin, their golden wedding. Four years later he died at the age of 81.

Youth at the Helm

All those whose names have made history in the records of the company entered its service at an early age. Alfred S. Johnstone, on whom the responsibility for the work's success largely rested when Henry Wiggin entered public life, had a very long service to his credit, having joined the firm at a very early age.

In 1877 Johnstone required an assistant and Gustav Adolph Boeddicker, a chemist from Westphalia, was chosen. Boeddicker came to the firm when he was 27 years old and spent 44 years in its service. After a few years he assumed entire technical responsibility for both the refining of nickel and manufacture of its alloys. The good results of his technical skill were immediately noticeable in a great improvement in quality of the product.

In 1888 Henry Wiggin & Company, Limited, bought the red-lead business of Thomas Adkins, at Smethwick. They continued to manufacture red lead, but in addition erected there cupola and reverberatory furnaces for smelting nickel and cobalt ore. Some years afterwards, when the demand arose, tin oxide was also made here, the plant being operated entirely by German workmen.

Between 1890 and 1900, part of the land and buildings at Smethwick was loaned to Dr. Ludwig Mond, the inventor of the Mond process of nickel refining, and the first Carbonyl nickel to be produced on an industrial scale came from this model plant.

The Twentieth Century

The twentieth century dawned prosperously for Henry Wiggin & Company, Limited. Hitherto the rolling of their alloys had been undertaken by the Bromford Mills, but in 1905 they purchased this business and moved the individual mills to Wiggin Street. Here they also put down a hot rolling mill.

1906 saw the beginning of a trade which was to make Henry Wiggin's name famous throughout the world—the manufacture of electrical resistance alloys. "Ferry," a nickel-copper alloy (known on the Continent as "Constantan"), was the first electrical resistance alloy to be put on the market by the company, and the manufacture of this alloy was followed closely by one of the nickel-chromium-iron series called "Chronic." Immediately prior to the beginning of the war the development of this side

(*Concluded on page* 306.)

Random Shots

"Marksman" appends the following from "furrin parts":—

"Hon. Sir Marksman and Editorial Friends,—There is in this section of earth pretty brisk buzz of business, and prophets are in an uprising tendence at the presently moment with expect of going on in same tune for summerly months. I am of a personality myself making some importings of U.K. goods and also a few chattels, which shall, I have expectations, do me a bit of all right in striking bargains with shall-be buyers in this place. You appreciate, my dear old cock, that selfly your freight chap friend is staunch loyalty member of Empire, and we make great giddy celebrates this year of His Majesty's Jubilee. On May 6 we make some din of firework to do him honourings for 25 years' rain.

* * *

"I have spoke of shall-be buyers in this place, and perhaps you appreciate, Sir Marksman, you can take horse to still water, but can you make him drink deep? Supposing we say I have a muchly stock of galvanised wire knetting to my warehouse and want to drop him as he is embracing to great room. I have met business friend and treated a few liquid refreshments to inflame his generosity and maker him rasher than wont. 'Come on, old sporting buff,' I egg him pleasantly, and off we step to wend ourselves for investigation of stock-in-trade. Perhapsly he buy some knetting, but if he don't I certainly send him debits bill for cost of drinkables to his account. You do not blame?

* * *

"Then, perchancely, I have some pig-irons for selling, and tell to a chap fellow he shall certainly avail to make purchase of large quant. because the price shall take an uprise in the nearly future. He may make to reply 'Rats,' or some suchly abusing epitaph as to say 'I am a disbeliever,' so I come at him quick and speak a mind at him with sharp retortings. Shall I confess, dear Sir Marks, that this rise to the market is a diphtheria of the imagination, and in my heart's bottom I have pretty shrewd conject that downfall of price is at hand? These schemings are dub tricks of the trade, isn't it not so; and in all parts of fashionable globe people shall employ them hopefully to catch a few small prophets. My customers they have their ideas to their heads, and I am entitle to mine own. You do not say no to that, I think? This is, however, a hard life of business.

* * *

"I am still hopeful to make you a visiting on your shores, and I am bursting of regret not to land for Jubilee celebrates, which I think shall make magnificent spectacles of bunting and other showpieces. If you should see pass H.M. you make loud cheer outburst to my account. Yes?"

"MARKSMAN."

Refractories Merger Plan Accepted

General Refractories, Limited, report that the majority of the shareholders of Messrs. J. Grayson Lowood & Company, Limited, the Sheffield firm of silica-brick manufacturers, have accepted their merger proposals. This will mean that General Refractories, Limited, will make a further issue of capital, a portion of which will be offered to the shareholders. Shareholders of Messrs. J. Grayson Lowood were offered cash or General Refractories shares: On the basis of 17s. 6d. for each 16s. paid share and 21s. 6d. per fully-paid £1 share, or for every five partly-paid shares held they could have allotted to them four General Refractories 10s. shares. The offer stipulated the acceptance of 75 per cent. of the Lowood shareholders.

A Review of Factors Influencing the Soundness and Solidity of Grey-Iron Castings

By J. L. FRANCIS

Amongst the host of activities that may be grouped under the heading of "Engineering" it is not far from the truth to state that one only involves the change of phase from solid to liquid and back again as an essential part of its accomplishment. In this fact lay the cause of almost all the troubles encountered by the founder in the production of castings. So many variables exert an influence in the processes of melting and solidification. Some of them are fairly well understood and may be controlled. Others are not so well known and more difficult to allow for, whilst yet again others contribute effects and have so far remained obscure. For the single field covered by grey-iron casting the known factors that must be appreciated, understood, and applied in the correct way are many and cover a wide range. It is doubtful whether they are always all borne in mind and given due consideration when trouble arises. Thus the purpose of this review is to bring at least some of the more important factors that either assist or militate against sound casting manufacture before the notice of the founder that they may be regarded and used with advantage.

Dissolved Gases

There is more iron melted in cupolas than in any other form of furnace. In no furnace is the molten metal more subject to the influence of the air forced in to cause combustion of the fuel and of the gases arising therefrom. This being so it is necessary that the correct amount of blast is used and the correct height of bed coke maintained. A missed coke split may cause a lowering of the bed so that the iron melts in an atmosphere containing an excess of free oxygen. Metal so oxidised always gives trouble when cast. Its running properties are greatly impaired and an excessive volume of gas is evolved during solidification. Some authorities hold that gases given off in this way are the sole cause of draws. Whilst many castings are defective due to occluded gas there is little doubt that a so-called gas draw is entirely separate and distinct from the draw exhibiting a very ragged interior and formed by the contraction of the liquid metal alone even if it contains no gas whatsoever. Large proportions of badly rusted, burnt or otherwise oxidised scrap in the charge will greatly tend towards a gassy melt. So also will sulphur if allowed to get much beyond the usual limits.

Shrinkage on Solidification

It is a well-known natural law that all liquids in passing from a higher to a lower temperature contract in volume. Cast iron approaching solidification is certainly no exception. J. Longden has claimed that in cooling from a liquid to a solid, ordinary grey iron shrinks in volume to the extent of 4½ per cent. Experience shows that some such volume reduction as this, due to liquid shrinkage, does indeed occur in spite of the tendency of the expansion during the graphitisation period to counteract it. Primary graphite forms as the iron sets, occupying at least four times more space than the iron carbide from which it comes. P. A. Russell[1] has given a very reasonable explanation of what happens. The casting, shortly after pouring, consists of four things: (1) The austenitic crystals; (2) liquid of similar composition; (3) solid graphite, and (4) the liquid phosphorus eutectic. Due to separation of some graphite the casting is now considerably expanded and a large amount of the expansion that ought to be so helpful in counteracting the liquid shrinkage has taken place while a very large portion of the casting is still liquid. Shrinkage of the solidifying liquid still takes place and the liquid is not now sufficient to fill all the space inside the solidified skin of the casting, thus leaving a shrinkage or drawhole. This hole naturally occurs at the part of the casting last to freeze, which is the place where the heat is dissipated most slowly. Some authorities hold that if cast iron is poured into a mould of sufficient rigidity to prevent outward expansion, thus making all the expansion go inwards to correct shrinkage, the net result should be no total shrinkage. Even then there is still about 1½ per cent. of net shrinkage, according to J. Longden, as compared with the 4½ per cent. if the casting expands freely. Theoretically the quicker a casting cools through its critical period the sounder the casting will be. The critical period is the time taken from the first moment the casting begins to set to the time when the last of the phosphide eutectic has solidified. That is to say, the time taken to cool the metal from 1,130 to 950 deg. C.

Casting Temperature

Although it is true that grey iron is far less sensitive to pouring temperature than most other metals employed for castings, yet study given to this aspect of the problem will be repaid by improved results. Melting in the cupola definitely restricts the degree of superheat that can be imparted. Superheating has been extolled as a means whereby a graphite precipitation much finer than that got from normal practice may be obtained. Under ordinary conditions of cupola melting it has been suggested that the temperature reached is not high enough for the period over which it is maintained nor long enough to cause complete solution of all the graphite nuclei. That is to say, nuclei are left in the melt which form starting places for the graphite to build on during subsequent cooling and solidification. Obtaining help in this way at the commencement encourages the formation of large and coarse graphite flakes. Imparting superheat to the necessary degree, however, is said to cause complete solution of all graphite particles if maintained long enough. From a melt so freed from nuclei graphitisation is very much finer.

Another explanation for the refining influence of superheat has been brought forward. In this the greater mobility of the particles are supposed to facilitate the kish or coarse graphite in its efforts to rise and separate from the bath. Some support is gained for this theory from the fact that jarring or mechanical agitation has been proved to expedite the action. Adoption of this view substantiates the old foundry rule of melting hot and letting the metal stand.

Generally speaking, cupola-melted metal should be cast as hot as possible for minimum dirt inclusions and pinholes. This practice, used in conjunction with properly constructed moulds and cores, should not occasion undue roughness or scabbing. A. E. McRae Smith[2] puts the whole thing in a nutshell by saying that "Good, hot, clean metal of the correct chemical composition poured into good moulds at the correct predetermined rate and correctly distributed, by means of the most suitable design of gates and risers, in the mould, will always give perfect castings." Attainment of all these ends is by no means a simple or easy matter. Some of the points mentioned in that statement of ideal conditions will be elucidated later. It may be emphasised at this point, however, that castings designed to withstand pressure should be poured with metal having a temperature of not less than 1,350 deg. C. That many more castings have been made unsound, due to being poured with dull metal, than ever were caused by pouring too hot, is an old and well-known saying, which is absolutely a true one.

Runners and Risers

When deciding on where castings should be run, it is well to bear in mind that the perfectly-cooled casting would be the one in which all the metal solidified at all places simultaneously. Under these conditions draws or shrinkage cavities could not develop. With complicated cored castings having sectional variations this, of course, is never attained, neither is it the only point for consideration. Where other circumstances allow, however, due attention paid to this important aspect would guard against ingates being placed at the heaviest parts of castings as they often are, or located where a hot spot would occur, even without such extra influence. Many types of casting present problems as to where and how they shall be run that are capable of more than one satisfactory solution. In these cases other factors than the single question of ideal cooling throughout the mass will decide one way or the other. For average-size castings of massive section and no complicated cores, the pencil gates, made popular by Ronceray, yield very sound results. Their success is largely obtained through the comparatively slow speed at which the iron fills the mould, allowing much of the liquid contraction to take place whilst the casting is being formed. Pencil gates have by no means a universal application. As has been pointed out, they serve well on castings of a particular type, and hot metal is absolutely essential.

Risers and feeders often do more harm than good. Indeed, in quite a number of cases their entire absence would have prevented a waster. Shrinkage defects and draws often occur from faulty methods of running and wrong design of feeders; where these must be used, wherever possible, rod feeding should be eliminated by adapting self-feeding methods, such for example, as the use of pencil runners and sink heads that feed by gravity. Castings to withstand pressure should on no account be fed with rods. Sometimes it may be found advisable to feed off the casting, but never into it. Another point against the rod feeding of castings for high-duty work is that they must be poured with metal of comparatively low-silicon and phosphorus contents. Metal of this composition is not so suitable nor so readily rod-fed as softer iron containing these elements in a greater amount, and having a more extended freezing range. Carefulness and skill are major requirements for successful rod feeding, otherwise the grain of the casting is sure to suffer. Another drawback to its extended adoption is the length of time taken for completion, especially with the heavier castings.

Denseners

The term "densener" is preferable to that of "chill" where it is not intended to promote cooling sufficiently rapidly to cause the iron to solidify white. Densener, in fact, explains the object in view, namely, to speed up cooling so as to avoid getting open-grained or porous metal at places where cooling left to itself would be sufficiently prolonged to give rise to this condition. Actually, denseners are used to help arrive at the ideal conditions of cooling already mentioned where the metal solidifies simultaneously at all parts of the mould. Employment of denseners certainly introduces an added hazard where it may be thought that enough risks already exist. However, the author's experience proves conclusively that their use is amply justified in that it appears impossible to get sound-

ness in some difficult castings without them. Judgment is, of course, needed as to where they may safely be put and how thick they must be for the desired effect. Too drastic an action, whilst it may not give white or even mottled metal, will cause a fine crack. If the usual precautions be taken to prevent condensation of moisture and the denseners dressed with care and all rust removed, no trouble will arise from the metal blowing or refusing to lay quietly on the metallic surface. It is as well to place the denseners so that metal has not to cover and lie on them horizontally.

Perhaps the majority of denseners form part of the mould or core, and may be subsequently fettled from the casting. Such is not necessarily always the case, for metallic inserts for imparting a densening effect may be used in heavy sections where they will eventually become a part of the casting. For these latter, particular care must be taken in deciding where they may safely be put without being objectionable on machining, unless, of course, as may happen occasionally, they can be completely removed by the machining operation. Sometimes denseners employed to ensure soundness, in such places as the bosses of flywheels, may be made sufficiently tapered to allow of them being driven out after the casting has set. This should be done wherever possible, as a heavy densener, remaining in position until the wheel has completely cooled off, may cause cracking through interference with the solid contraction. Copper denseners may be used where great difficulty in driving out is likely to be experienced, their greater coefficient of contraction helping in this respect. Oftentimes it pays to employ a solid-steel or cast-iron densener in place of a long cylindrical sand core. These cannot be easily removed from the casting other than by boring out when the job comes up for machining. If these are used, it must be remembered so to fix them in the mould in such a way that they can freely expand; otherwise, they may bend and cause a waster by this means.

Design

The design of a casting plays an important *rôle* in aiding or militating against the achievement of the perfect cooling conditions that are so desirable to ensure complete freedom from draws, whether due to pure liquid contraction, gas evolution, or both combined draws or shrinks holes, cannot be present in a casting that has solidified simultaneously from all points of the mould. Simultaneous solidification cannot prevent gas present in the liquid metal from coming off, but it does ensure that no collection of it takes place at a spot where liquid conditions prevail. The gas would still be there, but occupying microscopically small holes spread evenly throughout the casting mass, where for the majority of purposes they would not cause harm or be discovered.

Apart from a consideration of economy and ease of moulding which, although of extreme importance, form no part of these notes, design as applied to sectional thicknesses and changes and the radius of fillets is a salient factor in determining the chances a casting may have of freedom from shrinkage cavities and drawholes. Similarly, it is too often overlooked that all holes and spaces in castings have to be formed by sand cores or equivalent projections from the mould surface. Often this is accomplished with great difficulty, trouble, and no little expense in the foundry, and when these cores or projections serve merely to lighten a casting, this is attained at a cost which is not justified by the result achieved. Another aspect of the case is that, although sand distributed in this way takes weight from a lump of metal, it does not necessarily shorten the time taken for it to cool. A contrary effect may be set up, and the trouble aggravated by taking the surface of the casting right into its heart, where the defect will show itself later. Unfortunately, real appreciation of these points is not manifest by designers and draughtsmen as much as could be desired. Admittedly, the matter is not always a simple and straightforward proposition, sometimes being apparently of a contradictory nature, when, maybe, on one occasion the foundryman complains because a section or boss is too thick, and on another explains that a casting contains a defect as a result of the section having been lightened by taking some metal out.

To quote from a Paper by C. W. Briggs and R. A. Gezelius:[3] "There are as yet no definite rules of design which can be promulgated for every case, but it is possible to take specific cases and from them point out some generalities which might apply to similar designs. Accumulations of material are amongst the greatest dangers tending towards draws and cracks. For constructive reasons it is not always possible to avoid them, but the designer can minimise the danger by providing gradual transitions from light to heavy sections." Heuvers[4] has suggested a simple and convenient method whereby the influence of individual cross-sections may be determined. This consists merely of inscribing circles within the cross-sections to be examined. Fig. 1 illustrates the method. "The accumulation of material in the design on the left, as shown by the areas of the inscribed circles, is 80 per cent. greater than that of the more correct design." Many similar cases will no doubt

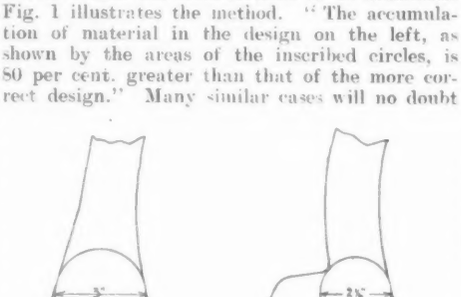

Fig. 1.—Showing the Application of the Principle of Inscribed Circles to Casting Design.

be brought to mind by a glance at the simple diagram and a circle drawn inside the heaviest sections gives in terms of its area a ready means of comparison.

Fillets are very necessary to avoid sharp corners and reduce stress concentration at changes of section. When they are constructed with too large a radius they become a definite disadvantage in some cases by exaggerating the mass of metal. Many of the points raised here may appear just plain common sense, and indeed it is just this which is largely required in elucidating these problems. When a casting repeatedly turns out unsound, panic legislation is often resorted to whereby the ideas of several persons may be adopted by making many alterations all at once. This is to be deprecated in that more than one of the modifications may tend to produce the same effect, which possibly as a result becomes over-emphasised, thereby causing a waster through too much cure. Also even if this does not happen unless alterations are made more or less singly, it is not possible to judge of their real effect and allocate to each its proper value in overcoming the trouble. Nothing is more annoying than not to be able to say just what has been the cause of a casting, that has given much trouble, coming out successfully at the end of a campaign of experiments. It is very necessary and desirable to be able to point definitely to the modifications made and state exactly what influences have been instrumental in gaining success. Often the same methods can be applied with equal advantage to other castings. A welter of alterations all brought into play at once causes confusion.

Chemical Composition

Chemical composition is a most important factor exerting a decided influence on the soundness of castings. Even though all the other factors discussed may be ideal, chemical composition alone is sufficient to nullify their combined effects. P. A. Russell, in the previous reference, has recorded some apt remarks on the subject. Soft irons of high silicon certainly tend to shrink less but are more liable to drawing, as they have a wider solidification range. A high phosphorus content also prolongs the period over which solidification takes place, with similar effect. Conversely, manganese shortens the freezing range and is very helpful, so that the more manganese there is present, up to 1.0 per cent., the less tendency there is for drawholes. Again, the author would take this opportunity of stressing the benefits to be derived from the presence of manganese in castings up to the figure quoted, at any rate for the majority of grey-iron work. These have been set out in an article[5] published previously in this Journal. Whilst on the subject of manganese it is as well to remember a type of defect described by F. J. Cook[6] as being caused by the elements silicon and manganese in certain ratio. Briefly stated, the trouble, which appears as a form of inclusion in the metal, may be safely guarded against by always ensuring that the silicon content is at least 0.5 per cent. higher than that of the manganese.

Russell expresses the opinion, with which the author entirely agrees, that cast iron, to be free from serious drawing trouble, should contain less than 2.0 per cent. silicon and 0.7 per cent. phosphorus, with manganese greater than 0.6 per cent. and a total carbon higher than 3.1 per cent., but not too high. Regarding the latter element, between 3.0 and 3.3 per cent. is a good range, upon which more will be said further on. One other reason why soft irons exhibit a tendency to draw is that the coarse graphite flakes tend to clog the liquid iron and phosphide eutectic during the critical period, thus interfering with the filling up of the deficiency, caused by the shrinkage, by natural feeding from the runners and risers.

Pig-Iron

Much is heard nowadays of refined pig-irons. There exists little doubt that their use has come to be more required for the production of high-tensile irons from the cupola. The duties that modern iron castings are called upon to fulfil are in some cases exceptionally severe, and the tests asked for from bars cast on them may be similarly described. To achieve success under these requirements, pig-iron of hypo-eutectic composition must be employed in cupola charges, so that the resulting mixture may be also of this nature. Steel scrap may be used with pig-iron containing carbon well in excess of the eutectic figure to attain the composition mentioned, without using refined pig-iron at all, but skilled close control and expert supervision must be available, otherwise the method is sure to fail. Even under the best conditions, the attempted economy may prove dearer in the long run, because to be really effective heavy steel percentages must be used, tending towards irregularity of the final product and requiring a specialised form of cupola practice.

Irons of eutectic composition have all the characteristics needed for making definitely sound castings. There is no possibility of segregation or piping, while the shrinkage of castings made from such alloy is very small. It has the lowest melting point, and runs well because there are no crystals in the mother liquor, and the liquid melt passes into the solid stage without any ancillary agency. Actually, however, total-carbon contents of refined pig-irons are often well below the eutectic amount. That is to say, they are definitely of hypo-eutectic character. Hypo-eutectic irons give rise to foundry difficulties of their own. They pour

badly and pipe or draw. Thus it is, in spite of the fact that, as the total carbon is reduced below the eutectic value, the tensile strength rises, it is well to endeavour to meet specification requirements with a total-carbon percentage of not less than 3.0 per cent. in the casting. Under this figure a different casting technique is required approaching more nearly to that of steel or malleable cast iron, where larger gates and risers are used and more shrinkage allowed for on the patterns. Even then the extra difficulties due to the rapidity of the metal in losing its running properties are still to be contended with. Frank Hudson,[7] in a Paper presented to the Chicago convention of the A.F.A., says as follows:—"By reducing the total carbon, silicon, phosphorus and manganese, and by increasing the sulphur, an iron with the lowest freezing period is obtained. However, this would not be good practice used indiscriminately. Trouble certainly would arise due to lack of fluidity, and hard castings would be produced. The bulk of the information on hand relative to this question suggests that the manganese and sulphur should be constant around 1.0 per cent. manganese, with the sulphur not exceeding 0.10 per cent. and the necessary variations made in the other elements. In the author's experience, it has been found that for high-class work the total-carbon content should not drop below 3.0 per cent., and for cylinder work, having variation in section, an increased amount of total carbon up to 3.5 per cent. is desirable. The present-day tendency for total-carbon contents below 3.0 per cent. is not essential for general foundry practice, and leads to difficulties."

Retention of Inherent Properties

Whilst dealing with the question of pig-irons and their influence in producing sound castings, one other point is worthy of mention. It is the so-called property of heredity, or the passing on of characteristics, whether good or bad, from the pig-iron to the castings made from it. Much argument has raged round this subject, but the author is convinced that it is a factor to be reckoned with. R. S. McCaffery[8] has written that certain irons retain their characteristics to a greater or less extent after remelting a number of times. Certain temperature conditions in the blast furnace cause some reaction to predominate at definite temperatures and produce definite end products or compounds in the iron. If, then, on remelting this temperature range in which the compounds were formed in the blast furnace is not attained, or if it should be reached, but only for a short time, then the compounds formed at the higher temperature persist, and the iron only liquifies. On cooling and solidifying again, it has the same, or approximately the same, compound composition, and retains, therefore, to a greater or less extent its original properties. If this be true, it explains much, and is at least one good reason why it is not good practice to employ pig-irons all emanating from the same blast furnace, for by so doing any pronounced characteristics possessed by the pig-irons may come to be exaggerated in the resulting castings, being similar in its effects to in-breeding.

Effect of Alloys

Progress in the introduction of the rarer metals into pig and cast irons has been rapid and widespread, so that it is fitting to end this summary with a few remarks concerning this most up-to-date development. As soundness has been the main theme of these notes, it is the influence of the alloys on this property alone that will be dealt with. It is not intended to take into account the modifications brought about by large percentage additions of alloys such as are present in austenitic and other special irons, but merely the improvements that may be expected from the introduction of comparatively small ratios of up to about 2.0 per cent. into ordinary grey irons such as are in every-day production and use.

Most of the elements so added effect soundness in so far as they remove gases and act as scavengers to the melt. Aluminium increases the solidity and fluidity of cast iron, removes oxygen and generally degasifies the melt. It also has a grain-refining action. Titanium deoxidises and removes nitrogen. Uranium has no appreciable effect on shrinkage or fluidity, but also eliminates oxygen and nitrogen. Vanadium is a powerful scavenger. It, too, unites with nitrogen. Zirconium removes oxygen and nitrogen, and in certain respects acts as a substitute for manganese, as it counteracts sulphur.

Nickel, whether added alone or in conjunction with chromium or other metals, is the most outstanding element in this field of achievement. It is also used to the greatest extent with chromium second. Simultaneous solidification of the iron in the mould has been stressed as an ideal combination that would entirely eliminate unsoundness and yield a casting of uniform density and homogeneity. Indirectly, nickel additions help considerably towards this end by eliminating the wide range of structures which normally result from different cooling rates of the various parts. It has been shown how variation of sectional thicknesses and large bosses associated with thin walls give rise to shrink holes and porosity. Frequently this trouble is deep seated and is not revealed until after machining or hydraulic testing. An addition of nickel, of from 1.0 to 2.0 per cent., is very effective in overcoming trouble of this kind, and gives increased fluidity of the molten metal, accompanied by decreased shrinkage. By the use of nickel, denseners can be dispensed with in most cases.

Many other metals enter cast iron as alloys that have received no mention here, because their main functions act in other directions and are not primarily concerned with imparting soundness.

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Irish Light Castings

Mr. David Frame, the managing director of the Hammond Lane Foundry Company, Limited, Dublin, in a statement to the Free State Prices Commission, during an investigation into the prices of materials used in the building trade, said that the shareholders of the firm had got 15 per cent. for the year 1934 and one bonus share was being issued in respect of every four shares they held. The company's capital would be increased from £50,000 to £75,000. A very large foundry, Mr. Frame added, was being put up in an entirely new building, and they had also got new furnaces. The money for the bonus shares was being provided out of accumulated reserves. The additional capital was provided, first to wipe off an overdraft which they had had for two years and secondly to allow for increasing trade. The overdraft arose from capital outlay. When he began with the company it had a capital of £2,000. The chairman of the Commission suggested that the concern was making a proportionately enormous profit, but Mr. Frame said he would only call it fair. On the question of reductions in the prices of his company's products Mr. Frame said their profits did not warrant any reduction. Their sales were up 25¾ per cent. over the year before and their profits 35¾ per cent., but that was only gross profit. The net profit this year was only 2¾ per cent., which allowing for expansion, he did not think was a reasonable profit. When Mr. Frame referred to prices of products similar to his firm's in England and Northern Ireland, the chairman said these offered no analogy, as there was no firm in Great Britain with the unique situation of the Hammond Lane Foundry in the Free State.

The Copper Agreement

By "Onlooker."

Copper history has been in the making during the past few weeks, for on March 29 finality was reached in the discussions on a curtailment plan and as a result there is to be a very fair measure of reduction in output during the second half of this year. In short, the scheme means that, excluding Russia and Japan, there will be a scaling down of 75 per cent. of production outside the United States, and the tonnage cut is claimed to be 240,000 tons per annum, this reduction to be, by agreement, based on current output, so that it would be wrong to draw the conclusion that last year's figure is to be brought down by this amount. Canada gives her sympathetic approval to the scheme, and possibly part of her copper may be held off the market for a time, but there is no claim that the Dominion is an active partner in the plan to reduce production.

Just what plans the various copper-mining interests have for 1935 is uncertain, but it may be taken as quite certain that world output of the red metal during this present year will not fall short of the 1934 total by half of 240,000 tons. As far as one can judge from the rate of output when agreement on the curtailment plan was reached, the net reduction on a full year is likely to be in the neighbourhood of 100,000 short tons, but it is, of course, quite possible that consumption will improve, for there can be little doubt that munitions are going to account for more copper in the immediate future. It is generally thought that the producers in framing up their scheme counted on an increase in the rate of consumption, but to offset this there will most certainly be more scrap available, for at the present price level secondary copper is more in evidence, and as the quotation improves, hidden stocks will be uncovered. In the opinion of the writer, these reserves are not limited to scrap only, and should electro climb to, say, £45 per ton there is every likelihood of additional quantities of virgin copper making their appearance.

As a matter of fact, much depends upon the ultimate price level reached, and in this connection one recalls the statement made last autumn that the Rhodesians would not welcome anything higher than £35. This was not an official announcement, but it was accepted at the time as being representative of Rhodesian opinion, even though other interests may have held a different view. At the time of writing, electrolytic copper is standing at about £36 and is talked a good deal higher, so that it looks as if the Rhodesians are going to be disappointed! However, in all seriousness, the producers doubtless realise that there is risk in pushing the advance in copper values too fast or too far for they know well enough the dangers inherent in price inflation. Unfortunately, there are aspects of the copper situation which cause a certain amount of anxiety to anyone who brings considered judgment to a summing up of the position as it is to-day, and of these not the least dangerous is the speculative activity on the standard market.

While it may be perfectly true that the speculator is not the originator of a rise, the support he gives to the market may easily carry things too far, and there is a real danger in copper to-day that the situation will get out of hand unless the public is kept very well posted on facts and figures. For the present those who are having a dip into copper as a means of making money quickly undoubtedly hold the view that the outlook is so good as to warrant a considerably higher quotation. But are things really so much better than they were?

XUM

Composite Rolls

REVIEW OF TYPICAL DESIGNS IN USE

Report No. 113 of the rolling-mill sub-committee of the Verein deutscher Eisenhüttenleute, published in "Stahl und Eisen," deals with the use of roll rings and ring or composite rolls in modern practice. The author, H. CRAMER, points out that the cutting of rolls for the rolling of shapes and light sections of unusual dimensions is a costly item in modern rolling mills. In the case of rolls for heavy sections, such as rails and structurals, several passes are provided on a single roll and the whole length of the barrel is used, which precludes any marked economy in the turning and machining of the rolls. Matters are altogether different in rolls used for rolling small shapes and sections, which are usually rolled on double-duo or small three-high mills, only one pass being made between each pair of rolls. Each pass being independent of the other facilitates rapid adjustment of the rolls and permits small errors in calibration to be readily corrected. The replacement of defective rolls and interruptions in a rolling programme are, moreover, infrequent in mills of this type. As long as it is possible to work with open passes, the cost of turning a roll is determined solely by the size of the section required. Thus to roll a section of the shape shown in Fig. 1*a*, only the shaded portion *a* in Fig. 1*a* need be turned from the upper roll and portion *b* from the lower roll, the rest of the barrel remaining unused or may be turned for other open passes later. On the other hand, if a closed pass is cut for the section shown in Fig. 1*c*, the whole length of the barrel must be turned, which not only considerably increases the machining costs but makes rolling costs much greater than when using open passes. To reduce these costs by using only a few closed passes or to dispense with them altogether is not practicable with certain sections, as with some sections open-pass rolling is rendered so difficult and the time of adjustment made so long that whatever is saved in turning and machining costs is more than discounted by the increased costs of rolling.

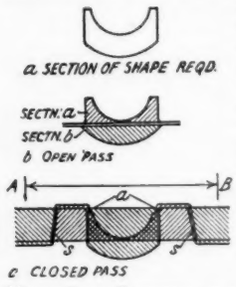

FIG. 1. — SECTION OF SHAPE (*a*) REQUIRED, WITH OPEN (*b*) AND CLOSED (*c*) PASSES NECESSARY.

Where passes are provided along the whole length of the barrel, provision may be made for the subsequent use of that part of the barrel not immediately employed, but in the first instance the high cost of turning a roll must be met. Several methods have been evolved to reduce roll-making costs, but without much success. Thus eight similar closed passes are provided along the barrel, when only one is required, in the hope that repeat orders may enable the seven extra passes to be utilised. If repeat orders are placed, the cost of making the roll is sufficiently spread over to warrant the first high cost, but usually the demand for small sections of special shape is too small to permit full use to be made of the extra passes. The first cost may be reduced by providing only one closed pass along the barrel and a series of blind passes which can be later cut to the required shape. A practicable plan followed here is to make the width of the blind passes progressively greater, say in steps of 1 mm. from 20 to 26 mm., where seven blind passes are provided. A third method is to cut the closed pass in one end of the barrel and leave the rest of its length available for subsequently cutting open passes as required. The cost of making a roll of this type is less than in the two previous methods, but apart from the high first and subsequent costs these methods possess various serious drawbacks and introduce a number of difficulties in actual rolling.

The disadvantages of these methods have led to the evaluation of "ring rolls," comprising rings mounted on the rolls, such rings being of a width sufficient for cutting the pass required with proper allowance for the edges. Thus, for the pass shown in Fig. 1*c*, a ring of width AB is required. These rings are secured to the roll barrels by various means, typical examples being shown in Figs. 2, 3 and 4. In Fig. 2, the roll ring is secured laterally to the barrel by the nut *a*, whose diameter must be the same as that of the roll neck. Nut *a*, which is right-handed or left-handed, according to the direction of rotation of the roll, is secured by the bush *b* and the key *c*. On the other side of *b* lies the collar of the roll bearing. The roll ring is driven by the roll through the feather key. In using this form of attachment, the bore of the ring must be accurately machined and make a good fit on the roll barrel. Owing to the heating developed during rolling, the ring usually loosens gradually, and this is the main disadvantage of this type, and which also precludes the use of chill-cast rings.

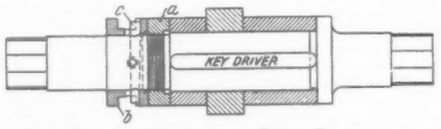

FIG. 2.—ATTACHMENT OF ROLL RING WITH NUT AND KEY.

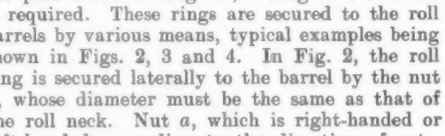

FIG. 3.—SHRUNK-ON ROLL RING.

These disadvantages are overcome in the arrangement in Fig. 3, where the ground coned ring is shrunk on to the ground coned barrel, which thus dispenses with means for securing and driving the ring. Laterally, the ring is also bushed and keyed. But to prevent the ring loosening on getting hot in rolling and slipping under high rolling pressure, it is essential to shrink on the ring at a fairly high temperature, which again prevents the use of chill-cast rings. A suitable steel for these rings is a manganese steel of 1.2 per cent. Mn and about 0.5 per cent. C. A special hydraulic stripper is also required for removing the ring from the barrel after use.

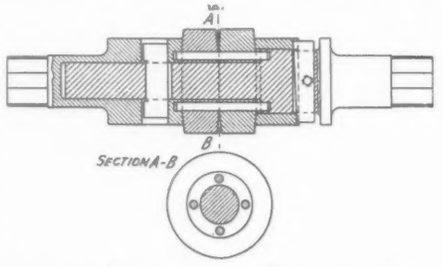

FIG. 4.—COMPOUND RING ROLL WITH FOUR KEYS.

Further improvements are incorporated in the design shown in Fig. 4, where the barrel is made in two parts, securely keyed together after the roll ring has been mounted in position. As the diameter of the barrel, owing to its sectional design, can be made smaller than the diameter of the roll neck, more durable chill-cast rings can be used than in the two previous methods. On the other hand, a high-grade chrome-nickel steel must be used owing to the reduced diameter of the barrel. At the side the ring is bushed and keyed. The ring does not run slack as easily in this arrangement as in the previous ones, as the heat evolved does not reach the centre of the ring so quickly owing to its greater width. Also, the four driving keys counteract slipping.

The use of roll rings reduces the machining of the passes to a minimum, and the work entailed is purely determined by the dimensions of the shape required. Re-dressing is also limited to the roll ring, and does not embrace the barrel. The cast of the individual rings is comparatively small, although the provision of a barrel with rings throughout its length would cost more than dressing and machining the roll itself. Mills which roll large quantities of shapes and sections have adopted the use of ring rolls from considerations of economy, and have put up with their various drawbacks. On the other hand, other mills rolling only a small tonnage of shapes still employ the direct dressing and machining of the rolls.

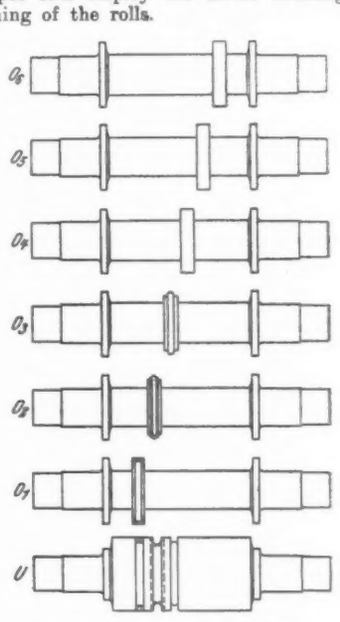

FIG. 5.—SET OF SINGLE-ROLL COMPOSITE ROLLS.

A more recent type of ring roll, designed by Hermann Irle, G.m.b.H., of Deuz-Siegen, claims to remedy the disadvantages of previous types, and consists essentially of a series of integral ring rolls, as shown in Fig. 5. The bottom roll U is provided with six separate top rolls O_1 to O_6, on each of which the ring is located at a different point along the barrel. To dress the rolls for a particular section, the necessary pass is cut in roll O_1, and in the corresponding part of the barrel of U, so that only the shaded portion has to be machined. The second section is provided with a pass in roll O_2 and its corresponding position in the barrel U, and so on along the whole length of U. Thus, for six sections seven rolls are required. More complex ring rolls have also been evolved for three-high and four-high mills, and with two or more rings on each roll, each ring being dressed and machined according to requirements. The cost of turning and finishing the rings is reduced to the minimum, while there is also a considerable saving in roll costs as against the old cylindrical rolls. The principal advantage claimed for these new ring rolls is that rolls of standard composition and dimensions can be used, making these rolls suitable for all mills, and not only for those rolling shapes and sections.

Frit Kilns and Fritting*

By J. H. Davidson, M.Sc., F.I.C. (Chief Chemist, Messrs. C. E. Ramsden & Company, Limited, Stoke-on-Trent)

By fritting is understood the conversion, more or less completely, of a number of very dissimilar materials into a fused mass of the nature of glass. Enamels are similar to pottery glazes in that they are "glasses" fused on to the surface of an underlayer; of metal in the case of enamels and "clay ware" in the case of pottery; in order to produce an impervious surface and to improve the appearance of the article in question. Like pottery glazes, enamels may be either leadless or contain a fair proportion of lead oxide; but there is no parallel in enamels to the soft raw-lead glazes used in certain sections of the ceramic industry.

Most pottery glazes are compounded of two sections, a fritted and an unfritted portion. Wet-process enamels consist chiefly of frit, but they also contain a certain percentage of unfritted material, viz., raw clay and a little borax, magnesia or some similar material added for the purpose of "setting up" the enamel and keeping it in suspension, so that it is in a suitable condition to be sprayed. This unfritted material enters into combination with the enamel frit during burning on, and is an essential part of the composition of the finished enamel. In a pottery glaze, a large proportion of the constituents of the glaze may be added to the mill mixture in the raw state, as the temperature and duration of firing is sufficient to ensure that all volatile matter is evolved and the glaze, as a whole, matures to a homogeneous mass. With enamels, however, the temperature of burning on is much lower and the duration of firing very short; so that if the finished enamel is to be homogeneous and have a smooth, even and brilliant surface, combination between its constituents must be brought about as completely as possible before the enamel is fused on the metal.

The Objects of Fritting

In the first place some of the chief ingredients are soluble in water, and if a mixture of the various raw materials, intimately ground together with water, were applied as an enamel, the soluble salts would rise to the surface of the enamel by capillarity during drying, thereby reducing the fusibility of the remainder of the enamel and spoiling the surface of the fused enamel. Further, some of the most important constituents of an enamel batch lose a considerable proportion of their weight in the form of volatile gases when being converted into an enamel; and if this expulsion of gases occurred during the brief period an enamel was burnt on to the metal, time would not permit of the interaction between the materials to proceed so far as to produce a "glass" free from gas bubbles, and in which the different oxides were in stable combination, or perhaps better described as in homogeneous mutual solution in one another. (The opacifying agents, of course, remain in suspension.)

The losses in weight experienced by some of the materials during fritting are as follow:—Borax, 47.3; soda ash, 42; nitrate of soda, 63.5; limespar, 44; magnesium carbonate 52, and boric acid 43.7 per cent.

As mentioned by Dr. Mellor in connection with pottery glazes, etc., in his inaugural address as President of the Institute, the study of fused enamels on metal furnishes another instance of an "arrested reaction"; *i.e.*, a reaction which has not been brought to completion. The further this reaction can be carried before the enamel is applied to the metal, the less remains to be done in the enamelling furnace. In order that the constituents of the enamel can be brought into combination, it is necessary that they should be fused together into a more or less mobile fluid; and this in a refractory chamber which is attacked as little as possible by the raw materials, partly for the purpose of maintaining constant the composition of the enamel, but chiefly for avoiding expensive repairs to the melting chamber. High-grade refractory materials are used, preferably fairly high in alumina. The importance of producing good frits is evident by reason of the fact that all the work done on the ware will be wasted if the enamel is unsatisfactory. It is the final stage.

The simplest form of an experimental fritting furnace consists of a fireclay crucible which can be heated in a small gas furnace. The bottom of the crucible is pierced with a hole through which the melted frit drops into water as it melts. The fritting is not good, as the more fusible constituents melt and run through, carrying with them unattacked or only partially-attacked portions of the more refractory materials. The results of the fritting are more satisfactory if the frit is re-melted once or twice. Melting in a simple crucible gives better results as regards the frit, but is slow, as each charge must be melted down and poured out. The fritting, however, is good. On a large scale and for continuous fritting a furnace of the reverberatory type has long been used, and continues to be used up to the present, though such frit kilns have been superseded to a considerable extent by revolving furnaces.

The mixture of raw materials is charged on to the hearth of the furnace through one or two filling-on holes in the crown of the furnace, which are covered with fireclay slabs during the actual melting. The hearth of the furnace slopes from both ends towards the centre, and sometimes slightly from the back towards the front, where the tapping hole is situated. The tapping-hole is sealed during melting by means of a ball of clay or flint, which must be removed carefully when the frit is run off so that it does not contaminate the frit. Such furnaces are usually direct coal fired, the flames and fuel gases passing over the batch and being radiated from the crown of the furnace. In some cases a baffle is built in the crown of the furnace to prevent the flames passing directly to the chimney stack. The baffles, however, are rapidly attacked by the flames, fuel dust, and dust and fluxes from the batch. Ordinarily, the bridge is built solid. The kiln hearth near the bridge, and the bottom near the interior of the bridge, are locally heated by conduction through the bridge, and the heat distribution in the kiln is unequal. This leads to greater attack on the refractory materials, and may lead to the bridge bottom being eroded and the frit making its way into the fire hole. One method of keeping the bridge comparatively cool and preserving the brickwork is to have an air channel through the bridge from side to side. A further development is to connect this channel with the interior of the kiln, and so provide some warm secondary air at the bridge.

In Parkes' split bridge, apertures under the firebars communicate with canals opening in the top of the bridge, and thus provide a supply of hot secondary air to meet unburnt gases from the fire mouth, in addition to keeping the brickwork of the bridge cool.

The advantages of the "split bridge" are:—(1) Secondary air warmed by heat which would otherwise be wasted or actually deleterious to the kiln; (2) less danger of cold secondary air entering at a critical place among the fuel gases when let in over the fuel bed to burn off the smoke, and (3) the bridge brickwork is protected. With a split bridge, a shallow firebox can be used. There is not so much danger of smoke from repeated batings. If the firebox be made very deep and direct combustion from the surface of the fuel is checked, it acts as a gas producer.

The disadvantages of the old-type coal-fired stationary frit kiln are:—(1) Difficulty of keeping the temperature even and regular throughout the kiln; (2) difficulty of maintaining consistently oxidising atmosphere; (3) melting is irregular; (4) running off rather tedious, and it is difficult to empty the kiln completely; the kiln also cools down quickly; (5) high cost of repairs; the whole kiln, or the upper structure at any rate, may need to be rebuilt due to a local failure at the bottom of the sides or bridge, and (6) a continuous run, with night work, is necessary.

Firing such kilns with oil effects an improvement. The operation is cleaner, more economical and under better control; but the fusion is still rather irregular even when frequent stirring is employed. The heat cannot penetrate a batch pile rapidly. Whatever type of furnace be used, it is essential that the batch should be mixed as well as possible to ensure rapid and thorough interaction, and prevent running out of fluxes. Perhaps the most essential feature is the brickwork. The bricks or blocks should be thoroughly well burnt, of low porosity to reduce attack and, most important, of good shape with joints as close as possible.

When an actual gas producer is used for heating the frit kiln, pre-heated secondary air is drawn through channels in the waste-gas flues and is introduced into the furnace above the bridge, just where it is most efficacious in bringing about complete and rapid combustion of the unburnt fuel gases, and yielding a high temperature where it is most required. Though many enamel manufacturers still use this type of frit kiln, more modern and efficient types are superseding the old stationary frit kiln.

Objections to the reverberatory type, coal fired, are:—(1) Fuel costs are high in relation to the output of frit (material costs are, of course, the same); good fuel must be used, and much of the heat generated goes to waste; oil burners have, in later years, been adapted to such kilns, but the general efficiency is below that of the newer systems; (2) excessive erosion takes place on the flux line of the furnace, and calls for renewal or even rebuilding of the kiln at comparatively short intervals, and (3) discoloration due to unburnt fuel gases, fuel dust, etc., and also from roof droppings due to the high temperature at which the kiln is operated, and the fluxing action of fine particles of the fritting mixture floating in the furnace.

Semi-Rotary Furnace for Frit-Making

This furnace* consists of a steel barrel, mounted on rollers and rotated through reducing gears by means of a hand wheel. The barrel is lined with a refractory material, suitably bonded, rammed very tightly round a former, and then slowly dried out. The result is a homogeneous lining with only one joint. The barrel is in two halves, hinged at one side, so that when relining is necessary the upper half can be turned over into the supports provided, and the relining carried out expeditiously. An oil burner is applied at each end of the furnace producing reverberating intense flames, which ensure uniform heating of the interior. A hinged lid on the top of the furnace allows of the introduction of the charge.

The barrel is turned, after being heated up to melting temperature, to its extreme position on one side and the charge inserted. When the charge has fluxed on the exposed surface, the barrel is rotated to its extreme opposite position. The rotation is only between such upper positions as will leave the charging orifice above the surface of the frit. The charge is thus thrown on to that part of the lining previously exposed

* Abstract of a Paper read before The Institute of Vitreous Enamellers.

* McKinnell, "Trans. Ceramic Society," May, 1932.

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to the maximum flame temperature, and at the same time, the previously-covered section of the lining and a new surface of the charge receives maximum heat from the flame. Semi-rotation operates for every ten minutes or so. When the charge is finally poured the complete lining is clean and free from residue. When the frit is molten, this semi-rotation causes heavy convection currents which have the effect of producing a more homogeneous mixture. A hole in the lid allows the exhaust gases to escape. The plant has a cowl and flue over the furnace to take off waste gases, and also is provided with a rotating mechanism. The frit is run off through the charging orifice after the lid is thrown back. To obtain a maximum oxidising atmosphere, special arrangements are made for the introduction of secondary air into the heating chamber.

It is claimed that (1) after lighting up, a temperature of 1,350 deg. C. can be attained in 45 min.; (2) there is easy access for re-lining; (3) the furnace can be adapted for gas firing if desired, and (4) local heating and wearing of the lining is reduced to a minimum. When re-lining is required, both halves are re-lined, with a tamped-in lining, dried from four to six hours, and a thin layer of soft material applied at the joint. The top half is then swung into position and bolted, and the furnace then further dried. The complete operation takes 48 hrs. The space taken up is much less than that with the reverberatory frit kiln, and space is also saved by the compact storage of fuel oil. There is no ash, and night working is unnecessary, as with the ease of operation small batches of frit can be produced as required.

Rotary Furnaces

Sir W. G. Armstrong Whitworth (Engineers), Limited, have now developed a fully-rotary furnace of 600 lbs. frit capacity which has run completely satisfactorily.

The Teisen "Fulmina" Furnace consists of a mild-steel drum with conical-shaped mild-steel ends, and lined with highly-refractory special-shaped blocks. The rotation is secured by electric motor through reduction gears with an alternative manual drive, as is customary. The heat is supplied by a low-pressure oil burner with regulating valves for oil and air, a pressure gauge being supplied for the latter. The burner is supplied with a nickel-chrome swirler and the air supplied by a fan driven by an electric motor. The air is preheated by recuperation, by means of which some of the heat in the waste gases is returned to the furnace. The conical end at the burner allows for the natural spread of the flame, and so assists in bringing about complete combustion of the fuel oils. The recuperator is placed on top of the flue box and connected with the chimney. The flue box is provided either with an inspection door, through which samples of the melt can be taken, or with a turntable inlet bend for the same purpose.

As in all cases of rotary furnaces, the rotation ensures an intimate mixing of the melting batch, and rapid fusion due to the continuous exposure of melting batch to heat radiated from above and a freshly heated surface below. Operation is simple, since air and oil are easily regulated by means of valves, and the rotation is controlled by switches. Some figures supplied by Mr. Tiesen are:—*In column*: Capacity of furnace, 5 cwts. Firing up, 50 min. Melting a charge (including filling and emptying), 1½ hrs. Fuel cost per ton, 70s. Fuel cost per ton of frit, 14s. Production, 1½ tons per day of 10 hrs.

With the rapid heating up of the furnace it is not necessary to make a continuous run. The furnace can be closed down at night after emptying and re-started the next morning. Some 1,400 melts have been obtained from one lining, but a more usual figure is about 800.

System of Dr. Schmitz and Company, Barmen

These furnaces are made in various sizes from 1 cwt. to 10 cwts. There are three principal parts—the melting drum, the driving gear and the stand. The drum, as usual, is of steel, fitted with a refractory lining, and can be adapted either for gas or oil firing. The exhaust arrangement is fixed at the end of the drum opposite to the burner, and consists of a refractory-lined cast-iron door which turns on a vertically-fixed axle, through which the melting process can be observed. The exhaust gases are drawn off through pipes, and the waste heat is used to preheat the air for the burner and the fuel oil.

The burner consists of a burner case and sprayer. The latter is pierced by a slot suitably attached in a slanting position, which gives the air a revolving action. The oil is fed into the burner under natural pressure, meets the revolving air currents and is completely vaporised. The atmosphere in the furnace is well under control, and can be kept oxidising or reducing as required. The oil supply is best maintained at 70 to 80 deg. C., and should not be allowed to get hotter.

The Askam Furnace

This is the same in general principle as the rotating furnaces previously referred to, in that it consists of a steel cylinder bolted on to cast-iron end plates machined on the flanges, which ride on four flanged wheels, these being rotated by an electric motor. The motor can be cut off, and the drum rotated for pouring by means of a hand wheel. The drum is lined with high-grade firebrick. When possible it is most convenient to mix the batch in a room above the melter, and charge down an inclined shute into the furnace. It is stated that a 700-lb. batch can be poured and the furnace re-charged in 10 min.

The time taken to melt a charge depends upon the type of enamel being melted, a soft enamel being ready for pouring in about 1½ hrs., whereas a harder one may require 2 hrs. or so. An easily accessible charging door and pouring hole is fitted into the side of the melter, which can be emptied in a few minutes.

The inside dimensions of the brickwork of a 700-lb. melter are 2 ft. 3 in. dia. and 6 ft. 2½ in. long, and the charge, if raked level, would reach 11 in. at the centre and about 6 in. after melting. A 1- to 1¼-h.p. motor is required to rotate each melter, and the necessary fan motor for two melters requires about 5 h.p.

The oil consumption is about 8 to 8½ galls. per hr. (viscosity 70 sec. at 100 deg. Fah. on a No. 1 Redman viscometer), and air pressure to the burner 22 in. to 26 in. water pressure. An unusual feature of this melter is that a portion of the air is conveyed to the opposite end of the drum and injected on the centre line of the drum opposing the burner. The object is to ensure an oxidising atmosphere inside the melter. The burner used is different from the ordinary type. The inside jet at the nozzle is in the form of a bell, and this has a number of holes round its circumference drilled at a tangent. The oil is supplied to the centre of the bell inside, and the air entering these tangential holes whirls the oil round the interior, and distributes it in a fine film around the knife edge at the end of this bell. There is an annular space between it and the outer nozzle through which the balance of the air passes. In doing so, it removes this oil film in the form of vapour, and it is consumed inside the taper-burning brick. The bell jet is about 2¾ in. dia., and the burner brick is at about an angle of 120 deg., so that the flame is projected along the sides of the drum, to which it imparts the heat. It is stated that the ordinary type of needle-jet burner has too much tendency to project a flame along the central axis of the drum, and out at the far end, without giving up its heat to the brickwork.

The U.S. Smelting Furnace Company, Belleville, Illinois

This furnace has the usual sheet-steel drum with a cast-iron cone head fastened to each end. One cone is equipped with a hinged door which is open for charging purposes. Discharging is effected from the other end. The cylinder and cone ends are lined with special firebrick, backed with insulating material. The melting chamber rests in a cradle, supported at the centre by two trunnions resting in the bearings of the furnace stands, one at each side of the furnace. It is so well centred that it is easy to tilt the furnace into any desired position. The burner, installed at the charging end, can be adjusted to maintain oxidising or reducing conditions, and can be raised out of position when charging. The motors used are 2 h.p. to revolve the chamber, and 7½ h.p. to run the blower supplying a 2½-lb. air pressure to the furnace. It requires 230 galls. of oil to produce 7,250 lbs. of frit, or 70 galls. per ton. After this furnace is heated up to melting temperature, the burners are shut off and a batch of 1,200 lbs. is charged by hand shovelling. The furnace is then tilted to the angle of repose, which is about 35 deg. The surface of the batch becomes sintered, preventing the fine batch from being blown through the discharge end when the burner is lighted. When the burner is relighted, the frit commences to fuse and flow down into the bottom, leaving a fresh surface exposed to the heat.

This process embodies two features:—(1) The melted frit is free from any danger of overburning, as it is kept constantly at the fusion point of the charge; and (2) unmelted material is kept constantly exposed to the heat and rolls into the bath, thus reducing melting time and fuel consumption. The partial rotation is continued, one layer melting after another until the whole charge is fused. When this is accomplished, the rotation is continuous, the temperature of the melt increases rapidly, and the entire charge is matured in a very short time. When the frit is fused, the furnace is tilted for pouring by means of a large hand-wheel, and the flow of the fused material is under the complete control of the operator. It is stated that it is possible to melt 1,200 lbs. of raw batch, run off and re-charge in 2 hr. 40 min., giving over 7,000 lbs. of frit per 24-hr. day, and that the furnace can be raised from cold to 1,320 deg. C. in 20 min.

Advantages of Rotary Melting

With rotary furnaces, a more homogeneous and uniform product is obtained, with the following advantages:—(1) In the stationary type the heat must be conducted down through the charge, and this is slow. The portions first melted are liable to get overheated before the whole is melted. If stirred, melted and partly-melted materials are mixed, and the result cannot be so homogeneous as when the batch melts down as a whole; (2) running off the fused enamel is more rapid, and cooling down of the interior less marked; (3) attack on the refractory is spread evenly over the surface, and not concentrated at certain parts, *e.g.*, the flux line; (4) they can be preheated very rapidly from cold, so that day working is possible, the furnace being shut down at night. In that case, the rotating should be continued after the oil has been shut off until any residue enamel has formed an even glaze over the surface.

Instead of constant rotation, some advocate rotation a little at a time, at 10- to 15-min. intervals; at any rate, until all the batch has been melted, followed by continuous rotating. The enamel cannot get locally overheated, and can be run off as soon as it arrives at maturity, which it all does at the same time.

Though the general trend of this Paper indicates that the author considers that the "rotating" furnace is the most efficient, this opinion is not universally held. In a personal letter received from Mr. J. T. Gray, and read by permission of the writer, the following statements are made:—

"While the rotary furnace is generally considered to be faster in operation and is supposed to give a greater output than the static type, and is also considered to have a higher thermal efficiency, I have definitely proved that the

average time for smelting 1 ton of frit in a standard rotary smelter, giving an output of 500 to 550 lbs. of frit per charge, is about 13 hrs., whereas the time taken to obtain 1 ton of frit from a good-type stationary reverberatory furnace is 11.2 hrs. The oil consumption of the rotary furnace is approximately 105 galls. per ton of frit, and this is the same in the case of the static type. The above figures prove that the so-called speed and efficiency of the rotary smelter is a myth. Of course, the only real advantage with the rotary type is that you get a delivery of frit every three hours, as compared with eight hours for the stationary type."

The lecturer wishes to express his appreciation of the assistance rendered to him—particularly for the loan of lantern slides—by Dr. J. W. Mellor, F.R.S.; Messrs. Sir W. G. Armstrong Whitworth & Company (Engineers), Limited, Newcastle-upon-Tyne; Mr. Th. Teisen, Birmingham; Messrs. W. E. Hughes & Company, Limited, British representatives of Dr. Schmitz & Company, G.m.b.H., Barmen; Mr. J. F. Askam, Birmingham; and the U.S. Smelting Furnace Company, Limited, Baltimore, Illinois, U.S.A.

DISCUSSION

As chairman, Mr. W. Todd said the address had been of great interest, and the lecturer had done very well despite the handicap of not being able to use his slides owing to some misunderstanding regarding the provision of a lantern.

Recuperative Furnaces

Mr. Tiesen, in some comments regarding the different furnaces, observed that no mention had been made of the recuperative type, but the rotary type was undoubtedly the more efficient. Speaking of one of the earlier types mentioned, he said that so far as tamping in was concerned this could be done in any ordinary rotary provided they employed the correct material, which was difficult to obtain in this country. While he could see no special advantage in the arrangement of the "Schmitz" type, he believed the mechanical part was very good. In the "Askam" type the question of counter blast occurred, and its action was based on a quite well-known principle.

Mr. Davidson explained that obviously the unburnt fuel or fuel gases were due to bad regulation. He agreed with Mr. Tiesen in most of the points he had commented upon.

Life of Linings

Mr. S. Hallsworth mentioned that at the Parkinson Stove Company certain experiments with various bricks for melter linings had been made. They had been getting a total of 250 melts per lining, and were told that other people were obtaining 300 to 500, and that others were quite satisfied if they ran to 120 melts. At the time they were using a moulded type of brick, with a sheet-iron enamel, and the melts numbered 250. For cast-iron enamel with the same type of brick they got 180 melts. They kept in touch with the firm which undertook the lining of their furnaces, and decided to try ordinary firebricks, otherwise the arch-type brick. The result was that they reached 452 melts with a "sheet-iron" enamel, and 327 melts with a "cast-iron" enamel.

Even with arch bricks they had only got up to 452 melts and he would like to have information regarding refractories giving 800 to 1,000 melts with vitreous enamel.

The moulded brick supposed to be made specially for the melting of enamel was a high-silica brick, while the arch brick had a high alumina content. Mr. Davidson had made a strong point about the joints of brickwork being close together, and he (Mr. Hallsworth) had ensured a tight joint with the arch brick, although, of course, with the moulded brick they should obtain an even tighter joint. Mr. Hallsworth here produced an arch brick as an illustration of this close joining. It showed no melt running down the sides, which would have happened had there been a large joint, and the enamel was confined to the face of the brick. The melt had not forced out the cement, so that the enamel could not attack the edges of the brick. Regarding the melting of enamel, he felt that quite a lot of boiling and black specking in the shop could be attributed to under-melting or even over-melting. Most people could tell when a batch was over-melted, but he did not think it was quite so easy to recognise when a batch was under-melted. In such cases he rather thought that certain gases and variations in the enamel arose before the final stage of melting, with the result that when the enamel was applied to sheet or cast iron these gases came off, causing a black-specking effect. At the Parkinson works it had been proved that these minor boiling troubles were due to under-melting, especially for "cast-iron" application, and they could be avoided by melting the batch half an hour longer. If they added 1 per cent. of felspar for milling purposes the same trouble arose with certain enamels as in the under-melting of the frit, and this occurred more in cast-iron than in sheet-iron enamel.

Mr. Tiesen, referring to furnace life, said it was not a question of refractories. If the flame impinged on the brickwork it would go into the batch. It was the path of the flame which they had to control, and not the refractories.

The Chairman remarked that, in regard to the number of melts for the average lining, there were great variations in some brands of bricks, and this might be due to the impingement of flame contact.

Mr. Tiesen mentioned that the average figure on the Continent was 400 melts.

Continental Practice

Mr. A. G. Reed suggested it was unwise to make any definite comparison between the melting of enamels as used on the Continent and as used in this country. Having had over seven years' experience on the Continent, he could state as a fact that enamels there were not used anything like so hard as they were in this country. Hence this would have a marked effect on the number of melts obtained or the batches out of a melt. Continental people would be in a position of getting at least one-third more batches out of the melter than was usual in this country, on account of the enamels being softer.

Mr. Tiesen observed that this was quite contrary to his experience, and added that he was referring to "bath" enamel; "sheet" enamel would be in the neighbourhood of 600 melts.

Furnace Hoppers

Mr. England said there was one point he would like to warn them against. He understood it was said that it was good practice to mix the melt and shoot it down an inclined cylinder into the melter. While he would agree with the principle of this method, he would caution them when installing a melter not to get the incline at too great an angle. At the Blythe Colour Works they adopted the method of dropping the melt vertically. It was very difficult otherwise, and the raw materials had to be pushed down. He thought they were all agreed, despite a letter which had been read from a well-known supplier and consultant, that there was no comparison between the reverberatory type of melter and the modern rotary. For a number of years enamels had been made at the Blythe Colour Works, and in the beginning they used the reverberatory type. There was a feed of secondary air, but they did not use a recuperator because of lengthening the flame. Then two or three years ago they turned over to the rotary, and he could tell them this: that the average life of their melts per furnace was 500. He might say that they melted all types of enamel, from about the hardest "sheet" to the soft "bath" enamel and the wet-process "cast-iron" enamels. They had tried various types of brick. At the moment they were using Scottish, and he believed it was producing results as good as any brick of which they had experience. Their greatest trouble had been with the silica content of the bricks.

Influence of Frit on Lining Life

Regarding the range of melts, he knew one firm who had a Tiesen melter doing soft bath enamels which had a high percentage of fluorine, and also with soda and borax rather high as well, and it kept up a thousand or more melts per lining. He knew of another works where a rotary melter of similar type was in use, and only about 300 melts were obtained; but, as Mr. Tiesen pointed out, the kind of enamel certainly made a difference. That a hard enamel should have actually less wear on the furnace linings than a soft enamel, he thought they would accept as being generally the case. However, it was somewhat strange that these firms should experience such a wide variation, one with bath enamel and the other doing sheet work, melting a fairly hard-grip-coat enamel in it and only obtaining about 300 melts; and yet, he believed, with the same type of lining. The conclusion he came to was that there was a good deal in the skill of the operative. Possibly, as Mr. Hallsworth indicated—although in the case mentioned he did not know who lined the furnace—one vital point was in regard to the closeness of the joint in the lining. Another important matter concerning rotary melters was the prevention of the spalling of the bricks. He did not think they were troubled with actual erosion, so much as with the spalling of a piece of brick; perhaps ½ in. to 1 in. in thickness or perhaps a 3-in. or 4-in. section dropping into the enamel. He thought the main feature of a brick lining depended on the structure of the grog in the brick. In Germany they made a grog brick and held it together with clay. In this country they made a clay brick and mixed it with grog, and he thought that spalling was largely to do with the actual open-grain size of the brick. It formed one of the greatest difficulties which rotary melters had to face. In their experience at the Blythe Colour Works there was no comparison in the enamel which was produced by a rotary melter with that coming from a flat melter, the advantage, of course, being with the rotary. They were continually experimenting in regard to prolonging the length of life of their linings, and they regularly attained 500 melts or more. In conclusion, and commenting on an observation by Mr. Tiesen as to one enamel being "bath white" and the other for sheet work, Mr. England said he always thought that there might be some little point of failure which had escaped notice and which affected these divergences, and it was a matter to which they ought to pay some attention.

German and English Brickmaking

Mr. W. Noake, referring to the grog used in bricks, said the Germans apparently had some secret whereby they prepared their grog in a much better way than English manufacturers; or at any rate they were much more careful than the average English maker of bricks for furnace work. A good deal depended on the way in which they prepared the grog and graded it.

To temper the clay they might add certain quantities of grades of grog and grind them, making the grog into different sizes from the size put in. This was inevitable in a good many machines in this country. However, some firebricks produced here were of very good quality. In Germany a step forward had been made in utilising the rotary furnace. Instead of making the grog from previously-burnt material and crushing it up in a hard burnt state, which knocked all the edges off more or less, they made the grog in the rotary furnace and graded it in the raw clay.

If they were wise people, as he thought they were, they did not put it in a solid pan to temper it, but in a kind of dough mixer, which avoided knocking off the sharp edges of the grog and prevented rounding them, the same as they did in

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working with flints. In making the grog by the German method they retained the sharp edges of the grog, thus giving a better adhesive surface for the clay portion of the brick to fix on to, and in this way they obtained a more homogeneous brick. At the same time this very likely accounted for the occasional spalling which occurred in melting furnaces. He was hoping that Mr. Davidson was going to deal with points as to the best refractory brick for frit kilns, whether rotary kilns or stationary, but he wisely, perhaps, left that subject alone.

He had met a good many refractory makers, and quite a number of them insisted on certain mixtures never going into the edge runner pan, the grog being heavily serrated and put into a kind of dough mixer. This ensured a closer adhesion between the clay particles and the grog in the formation of the brick, and there was no doubt that the method applied by the Germans with so much care in this respect was one which produced good bricks. Probably this result was accounted for in that they made their grog plus clay, instead of in the reverse English way of using clay plus grog.

Scottish Fire Bricks

Mr. Davidson remarked that almost all German fireclays were essentially different from anything they had in this country. The nearest we had were some of the ball clays. This marked difference was in the long range which these German clays had between what was known as the sintering point and the melting point. In other words, some of these clays vitrified and lost all their contraction round about cones 1 and 2, yet did not actually melt until reaching cones 11 and 12. Thus there was room for a considerable variation in the degree of calcination. Before the mix was fully calcined they had this somewhat semi-vitrified state, and the clays were not so liable to run off as in their more friable English clays until brought near to the melting point, which was in Scotch fireclays very high.

Devon and Dorset Clays

Mr. Noake observed that in his experience the best results obtained from frit-furnace bricks was when a clay was made up for a Yorkshire firm of fireclay makers. They imported a ball clay from either Dorset or Devon. He himself should be inclined to a Devon ball clay in preference to the Dorset. He was speaking of some twenty or thirty years ago, and certainly the bricks produced were the best for frit kilns which he had come across. The very fine ball clays in Devonshire were very suitable for the purpose, rather more so, he thought, than the more friable clay in Dorset.

Vote of Thanks

Mr. W. H. Whittle (Chairman of the Institute), proposing a vote of thanks to Mr. Davidson for his interesting lecture, said such lectures were not only of value to the trade in general, but showed how varied were the results which different firms obtained from the use of similar material and similar appliances.

Mr. W. S. Grainger seconded, and said he had come to the conclusion that there was something in the old refractory furnaces still, especially in the recuperative type. He had been seriously considering, this last two years, which of all these perfect cylindrical types he should adopt, but when they came to inquire into their working it appeared that they were still troubled with all these different troubles of melting and spalling which none of them seemed to be able to cure, and droppings from the roof occurred just the same. There did not appear to be any great improvement in this respect, and he might mention that in an old furnace which had been condemned—and which they had decided to dispose of more than once—they continued to get eight batches per day. Each batch weighed practically half a ton, so that the output was approximately 4 tons per day per 2 tons of coal.

(Concluded in end column.)

Some Notes on the Reclamation of Grey-Iron Automobile Castings by Welding*

By Vincent C. Faulkner (Past-President of the Institute of British Foundrymen)

This Paper would have been of enhanced interest if it had been possible to enlarge its scope to embrace grey-iron castings in general. Unfortunately, however, in many branches of the industry insufficient confidence exists between the manufacturer and buyer of castings as to the practice of accepting castings which initially were imperfect in some degree. Where the ultimate buyer is the general public and not the specialist engineer, less reticence has been observed, and no steps are taken by the more enlightened manufacturers of such products to hide the fact that, as a policy, they refuse to scrap castings which can easily and cheaply be made serviceable by welding. Into such a category enter the larger manufacturers of automobiles, and the system adopted by one of them forms the subject-matter of these notes.

Division of Work

The reclamation department is divided into two entirely separate sections, one of which deals with the raw defective grey-iron castings, and the other with imperfections which show up during or after machining. Every morning all the defective raw castings are assembled in a marked-off area, and an inquiry, attended by the foundry superintendent, the metallurgist, the chief patternmaker and the foreman of the first welding section, is held. After diagnosing the defects and outlining the steps to be taken for their future elimination, the foreman welder decides which castings can be economically repaired, and they are transferred to his department. Here the castings are divided into three categories, the governing considerations being size of defect and size of casting. Thus, a large casting—say, a cylinder block—having a blow-hole up to about $\frac{3}{8}$ in. in dia., will be repaired by electric welding. The second group consists of large castings which have been cracked during either manufacture or handling, and for it a special plant has been provided. This consists of two gas-fired furnaces installed in parallel, with the welding bench situated between the discharging end of the preheating furnace and the charging door of the annealing furnace. Thus, from the point of view of handling, the castings make a U-shaped travel. The preheating furnace is about 25 ft. long by 6 ft. 6 in. wide, and is charged by the ram of a compressed-air cylinder. The heating is graduated and reaches a maximum at the discharge end. The firing is so arranged that the castings, mainly cylinder blocks, reach a temperature of 1,150 deg. Fah. (720 deg. C.). Welding is effected by the oxy-acetylene process, using what is known as the silicon rod. Immediately after welding, the castings are charged into an annealing furnace, which is in every way similar to the preheating furnace except that it is a matter of 7 ft. longer and that the heating is graduated in the inverse sense.

The third group consists of miscellaneous small castings, and these are preheated prior to welding on 3-ft. by 4-ft. benches provided with two gas-burners using an air-blast for combustion. Around the two flames are built up small stacks of castings. These, again, are welded by the oxy-acetylene process, and immediately after welding the castings are buried in sand contained in a tray positioned at the side of the hearth. The trays are of the same dimensions as the benches.

Machine Shop Defectives

The second department, which handles castings found to be defective during or after machining, also divides its work into two categories—those castings which can be repaired, without preheating, by the plastic-arc method, and those which require preheating and subsequent annealing, for which purpose resort is made to the oxy-acetylene process. It will be realised that much more valuable material is handled in this department, owing to the amount of work added by the machine shop, and complicated and difficult work is often accomplished. Yet if 3 hr. of welding time can reclaim a casting upon which 10 hr. of machining time has been expended, it is well worth while.

The electric welding machines, though normally housed in cabins, are made portable, in order that, if occasion warrants, the machine can be taken to the job. It is the practice in the particular works where these notes were taken, to weld cracks by drilling $\frac{1}{4}$-in. holes at the ends, welding the holes and for a short distance along the cracks electrically, and sealing the major portion of the crack by the oxy-acetylene process in the usual manner.

In this department, the preheating temperature prior to welding by oxy-acetylene gas is somewhat lower, being controlled between 1,000 deg. and 1,080 deg. Fah. (535 deg. to 580 deg. C.). Heating and annealing are carried out in ordinary gas-fired, muffle-type furnaces. It is not unusual for a 6-in. length of flange to be added, or a broken corner—weighing half-a-pound—to be reset. Aluminium castings are also repaired by electric welding, but not every grade lends itself to this treatment. It is the duty of the reclamation department so to finish a casting that it can be returned to the conveyor at exactly the same position at which it left it. For this purpose the department is well equipped with portable and machine tools.

An examination of a modern automobile castings-reclamation department provides ample proof that grey cast iron can be satisfactorily welded when adequate plant and facilities are provided. The fear, which apparently exists amongst engineers as to the unreliability of a welded grey-iron casting, has undoubtedly been fostered by the improvised methods, born of secrecy which exist in certain types of foundry undertakings.

* A Paper presented to the Welding Symposium on behalf of the Institute of British Foundrymen.

Frit Kilns and Fritting

(Concluded from first column.)

The Increased Tariff

The Chairman announced that through the co-operation existing in the trade the tariff on certain imported material had been increased by 15 per cent. from 10 to 25 per cent. The Wolverhampton Chamber of Commerce had taken an active part in the representations made, as had the Institute through the endeavours of the hon. treasurer (Mr. Grainger). They were aiming at a $33\frac{1}{3}$ per cent. duty, and while not content with the new concession, had welcomed the increase to 25 per cent. to see what effect it had on the trade. If the position continued unsatisfactory, other bodies together with the Institute would continue to press for more favourable terms.

Co-operation with the Home Office

Arising out of a question on the subject of factory inspection, the Chairman said he thought they could claim that most firms studied the welfare of their workpeople. They did not know whether the inspectorate was contemplating any recommendations to the Home Office in regard to any additional or extended regulations, but they were desirous of co-operating with the authorities. As representing the enamelling industry, the Institute was the proper body to make representations if any were considered desirable, and he thought he would be interpreting their views when he said they were prepared to co-operate with the Government Department concerned in providing any necessary safeguards for the welfare of the employees.

Sand Mixing and Aerating

THE V.S.K. MACHINE

Great interest attaches to the "V.S.K." patent sand-mixing and aerating machine, driven by means of a self-contained electric motor, petrol engine or other convenient method, which in the smaller sizes can be wheeled about easily by one man.

This is manufactured by W. C. Holmes & Company, Limited, of Huddersfield, and the basic principle of the design is an almost horizontal shaking screen, on to which the sand is thrown, spilt from a conveyor or a hopper-shaped receiver beneath the screen, and a high-speed rotating drum, having on the outside a series of hardened projecting steel knives which mix and aerate the

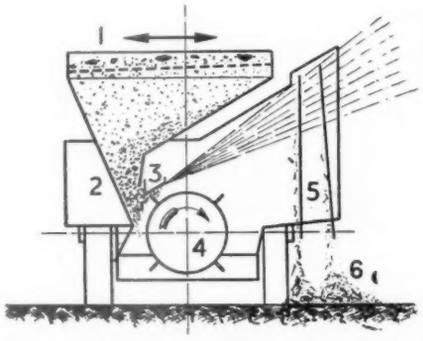

Fig. 1.—Vertical Section of the "V.S.K." Sand Mixer and Aerator (W. C. Holmes & Company, Limited, Huddersfield).

1.—Shaking sieve. 2.—Mixing chamber. 3.—Movable baffle plate. 4.—Rotating drum. 5.—Vertical double screen. 6.—Separated foreign matter.

screened sand in effective fashion and discharge it through a second screen, which is vertical and stationary, formed of two sets of steel wires with a space between, the separate foreign matter falling out at the bottom. In passing through the shaking screen the larger lumps are broken up and the hopper receiver delivers the material at the bottom on to the rotary drum, the knives or projections of which each take a definite amount. Included in the arrangement at the discharge point of the hopper receiver is a movable baffle plate, against which the sand is thrown with considerable force, giving a further breaking-up, grinding, mixing and showering

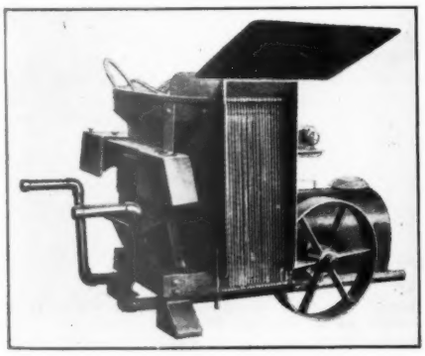

Fig. 2.—Sand Mixer and Aerator (W. C. Holmes & Company, Limited, Huddersfield).

action. By this means old used sand and new sand, for example, as well as different varieties of sand, can be mixed intimately and rapidly, giving a uniform blend.

A highly important fact is that the rotary drum, largely because of the knives, acts as a fan, giving complete aeration so that hot sand taken out of moulds can be immediately cooled and freed from gas, being ready at once for use in new moulds.

The machine is fitted with suitable wheels and handles for propulsion, and the whole construction is of a heavy and solid character to withstand the severe conditions of the average foundry.

A standard size of portable "V.S.K." machine has a capacity of 175 cub. ft. of sand per hr., and is driven by a 3-h.p. motor (or petrol engine), the high-speed drum running at 1,000 revs. per min. Some types of sand-mixing machine have not been a success due to various troubles such as rapid wearing of moving parts, high power consumption, non-uniform mixing, caking of damp sand, and great weight, but it is claimed for the "V.S.K." machine that it represents a practical solution of these and other problems.

Essentially, the design combines the advantages of the three different basic types of sand-mixing machine originally introduced, *i.e.*, the "propeller," the "comb," and the "cutter," whilst eliminating most of the disadvantages. The sand in bulk amount is propelled with great velocity, whilst at the same time being combed, cut up, and submitted to a milling action in spite of the light weight of the machine, easily transported as already stated, eliminating all the trouble of conveying sand to and from a central site. There is also no caking and sticking of the sand inside the casing.

Permanent Moulds in the Bronze Age

In a leading article in our issue of January 17 we promised our readers a photograph of the permanent moulds therein described. Through

Bronze Age Permanent Mould and Casting.

the courtesy of Messrs. T. H. Oliver & Sons, the owners of the quarry at St. Teath, Cornwall, whereat the mould was found, we are now able to fulfil our promise. The picture shows, in addition to the two halves of the mould, a white-metal casting which has been produced from it.

Copper Paint

Discovery of a new chemical process for reducing copper to a non-crystalline form, suitable for use in a liquid vehicle and giving in effect, the equivalent of liquid copper, is announced by H. M. Rice, metallurgist of the Nichols Copper Company, Chicago. By the new process, the metal, 98.3 per cent. pure, can now be applied in this liquid manner to form a virtual sheath or armour of copper upon almost any surface. The new product is not to be confused with common oxides or bronze powders. By virtue of the shapeless form of the tiny copper particles, which are so small they penetrate a 350-mesh screen, no minute gaps are left in the coating after application by spraying, dipping or by a brush. Laboratory and field tests are reported as indicating that the product should have a useful life of 4 to 10 years and possibly longer. It is said also to be highly resistant to acid and other corrosion.—"Steel."

The Effect of Arsenic on the Wear of Cast Iron

Piwowarsky, Vladescu and Nipper have already shown that small quantities of arsenic exercise a beneficial effect on the mechanical properties of cast iron, having observed that the addition of 0.3 to 1 per cent. arsenic reduces the "spindle-friction" wear to about a third of the value found with cast iron containing no arsenic. Owing to the difficulty of obtaining specimens of uniform composition, Piwowarsky and Söhnchen have repeated the previous work with four samples of almost identical composition except as regards the percentage of arsenic. The carbon varied between 3.59 and 3.66 per cent., graphite between 2.82 and 3.15 per cent., Si between 2.23 and 2.29, Mn between 0.59 and 0.61, P between 0.110 and 0.114, and S between 0.044 and 0.050 per cent., while the arsenic in the samples was nil, 0.555, 0.97 and 1.31 per cent. respectively. The wear was measured when the samples were submitted to rolling friction, sliding friction and to "spindle-friction" under the same conditions as previously employed by Heimes and Piwowarsky for determining wear values.

Under rolling friction, the wear was practically the same with the 0.5 per cent. As specimen as with the plain cast iron, but increased as the percentage of As was raised. Under sliding friction and "spindle-friction" the wear as measured by loss in weight diminishes gradually up to 1.3 per cent. As, as little as 0.5 per cent. As already causing the "spindle-friction" wear to fall. The improvement in resistance to wear was found to be 40 to 50 per cent. as compared with 60 to 70 per cent. found in the previous research. These latter values were obtained with a pressure of 5 kg. and a speed of revolution of 25 r.p.m., while the lower values were measured at the much greater speed of 700 r.p.m.

The wear increases linearly with the pressure between the surfaces in contact. In the case of steel, Eilender, Oertel and Schmalz found that a maximum value is reached with increase in pressure, but the present research with cast iron was not protracted to the determination of any limits as the specimens were only 1 mm. thick and thus too thin to withstand a high pressure. But it was observed that as the speed is increased to about 350 r.p.m. the wear becomes rapidly reduced in the 0.5 and 1 per cent. specimens, and that as the speed is increased to 1,350 r.p.m. from 350 r.p.m. the reduction in wear is practically unaltered. While some specimens showed little difference in wear at high speeds, the differences at low speeds became steadily greater as the speed was reduced. It is thus seen that the wear is determined by a number of factors and that the addition of less than 0.5 per cent. As increases the resistance to wear under sliding friction without reducing the resistance with regard to rolling friction, but that the improvement in resistance to wear depends entirely on the operating conditions.

Shipbuilding Orders

Messrs. R. & W. Hawthorn, Leslie & Company, Limited, Hebburn-upon-Tyne, have obtained an order from the Union Steam Ship Company of New Zealand, Limited, for a twin-screw passenger and fruit-carrying vessel to be fitted with Diesel engines. The firm have also secured an order from Messrs. Stephenson Clarke & Associated Companies, Limited, for a collier 175 ft. long to be fitted with triple-expansion engines by the North-Eastern Marine Engineering Company, Limited. This makes six vessels the firm have to build or lay down. An order has been received by the Burntisland Shipbuilding Company, Limited, from the Joseph Constantine Steamship Line, Limited, to build a coasting steamer of 1,420 tons deadweight. The propelling machinery will be supplied by the North-Eastern Marine Engineering Company, Limited, Sunderland.

XUM

This Week's News in Brief

Trade Talk

A Luxemburg metallurgical works has reduced the wages of its Luxemburg employees by 7 per cent. and of its Belgian employees by 15 per cent. as a result of belga devaluation.

The tender of Brown Bros., Limited, Rose Bank Ironworks, Edinburgh, has been recommended for acceptance for the installation of wave-making plant at the new swimming pool in course of construction at Portobello for Edinburgh Town Council.

The Low Moor Iron Company, Limited, are giving all the regular workmen at their Low Moor furnaces an extra day's pay in lieu of a holiday on Jubilee Day. In view of their continuous process of manufacture, it is not possible to release the men from work.

The directors of Messrs. Colvilles, Limited, have decided that it will not be advisable to have a stoppage of work at Dalzell Steelworks on May 6. The company, however, is to make payments of 10s. to every employee over 24 years of age, and 5s. to each employee under 21 at Dalzell Works.

The demand for rolling-stock and permanent-way material continues to be brisk. Messrs. Hurst Nelson, Limited, Motherwell, have booked an order for 30 underframes for container traffic wagons for the L.M.S. Railway Company. The firm has enough work on hand to occupy the present labour force until after August, and more men may be taken on from the waiting list.

According to a writer in "La Revue de Fonderie Moderne," the following is the approximate number of unattached foundries in France:—*Iron-foundries*: Large (above 500 tons monthly), 50; medium (from 100 to 500 tons monthly), 150; small (less than 100 tons monthly), 1,000. Total, 1,200. *Steel foundries*: Total 100. *Malleable ironfoundries*: Total, 40. *Bronze and aluminium foundries*: Total, 450.

Messrs. Davy Bros., Limited, Park Ironworks, Sheffield, have received a contract from the Government of the U.S.S.R. for a complete forging and rolling plant for the production of tyres for railway wheels, having an output of 36,000 tons per annum. The machinery includes a 3,000-ton press, roughing and finishing mills, marking and rectifying presses, charging machines, hydraulic pumps and accumulator, etc.

The shipbuilding yards and engine works of Messrs. Workman Clark & Company, Limited, Belfast, are to be closed down. The North Yard, Belfast, is to be closed altogether, and the South Yard and engine shops are being taken over by Harland & Wolff, Limited. The yards are being purchased by National Shipbuilders Security, Limited. The Cyclops Foundry Company, Limited, at Scotstoun, Glasgow, also belongs to Messrs. Workman Clark, Limited.

Speaking at the 33rd annual general meeting of Albion Motors, Limited, this week, Mr. N. O. Fulton, the chairman, explained that during the year the company was approached, in common with other firms, to put forward a chassis for tests with a view to establishing its suitability for Royal Air Force conditions of operation. As a result of competitive trials, held in November last, the firm had recently received an order for a substantial number of four-wheeled chassis from the Air Ministry.

A Lithuanian contract for electric cranes worth £10,000 has been booked by Messrs. Babcock & Wilcox, Limited, who have orders on hand ensuring steady employment for 5,000 men at their Renfrew and Dumbarton plants for several months. Plans for the extension of the Dumbarton works have been approved by the directors. The employees are being given a holiday with pay on May 6.

A part of the plant of the Motherwell Iron & Steel Company, Limited, which was sold for dismantling a few weeks ago, will be shipped to India for use in production. The consignment will include the 8-in. and the 10-in. mills. These mills were modernised and equipped for electrical drive a year or two ago, and are said to be capable of putting up a good productive performance. It has not been revealed whether the rolling plant has been acquired by an established Indian steel concern or by a new group proposing to enter the finishing-steel trade.

Large contracts for engineering material have recently been placed with home manufacturers by a Glasgow firm, Messrs. Edmiston Brown & Company, Limited, consulting contractors. They include orders for several steam turbines, one of which, of 2,500 h.p., is for driving a textile mill in India, while the others are for use in factories in this country. A battery of water-tube boilers has also been ordered by these consultants from Messrs. Babcock & Wilcox, Limited, Renfrew, and other contracts have been placed with West of Scotland firms for pumping plant, steel structures, etc.

Representatives of the European steel cartel and of the British Iron and Steel Federation, at Tuesday's conference in London, concluded an agreement for a period of three months that imports of cartel products into the United Kingdom should not exceed a rate of 643,000 tons per annum, 160,750 tons for the three months, with certain adjustments for other products. During this period negotiations for a long-term agreement will be actively pursued. Negotiating committees of the various sections will be appointed immediately. The British delegation undertook to request His Majesty's Government to suspend for a period of three months the operation of the increased duties which came into effect on March 26 last.

Personal

Prof.-Ing. Dr. Mont. Fr. Pisek, Professor of the Czech Polytechnic School at Brno, has been elected President of the Czecho-Slovak Foundry Technical Association for the year 1935.

Mr. Clarence I. A. Dubs has joined the board of the North British Locomotive Company, Limited, Glasgow. Mr. Dubs is a son of the late Mr. Charles Ralph Dubs, one of the original directors of the company.

Mr. and Mrs. John Cochrane, of Falkirk, celebrated their golden wedding last week. Mr. Cochrane was a moulder, and was employed by the Falkirk Iron Company, Limited, Messrs. McDowall Steven & Company, Limited, and the Mungal Foundry, Carron.

Mr. Frank K. Neath, B.Sc., has severed his connection with the Keighley Laboratories, Limited, and joined the staff of Messrs. Blakey's Boot Protection, Limited, Armley Malleable Ironworks, Leeds. Mr. Neath's new address is Fern Cottage, Mill Lane, Bramley, Leeds. Telephone: Stanningley 72047.

Wills

Petersen, Theodor, assistant managing director of Messrs. Callenders Cable & Construction Company, Limited ...	£9,039
Dickenson, J. H. S., of Sheffield, metallurgist-in-chief of the English Steel Corporation, Limited, and a special director of the Vickers Works ...	£6,680

Obituary

Mr. John Thom, Vice-President of the Institute of Marine Engineers, who died recently, served an apprenticeship with Messrs. William McKinnon & Company, Limited, Spring Gardens Ironworks, Aberdeen. In 1900 he was appointed managing engineer of the London Central Markets Cold Storage Company, Limited. In 1911 he superintended the erection of a cold store at Tarquah, on the West Coast of Africa, for the supply of ice and meat to the mines. He was a member of the Department of Scientific and Industrial Research under the chairmanship of Sir Alfred Ewing.

Mr. Robert Thomson, formerly of Messrs. Barr, Thomson & Company, Limited, Netherton Iron Works, Kilmarnock, died recently, in his 82nd year. Mr. Thomson served his apprenticeship in the old Vulcan Works, and became associated with the late Mr. John Barr, of Glenfield & Kennedy, in reconstructing the business of the late Mr. James Barr, which in 1897 was formed into a limited-liability company, under the title of Barr Thompson & Company, Limited. Mr. Thomson became managing director and carried on the business with marked success. He had an interest in several Indian tea concerns, and was associated with the Assam Engineering Company. Mr. Thomson retired from active management some years ago.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Sand Testing

To the Editor of The Foundry Trade Journal.

Sir,—I have read Mr. Frank Hudson's Paper with much interest. It is, indeed, a very valuable practical contribution.

His deductions from Fig. 1 are very interesting, and from personal experience I am able to corroborate his findings, having used a standard sand for green sand and dry sand for some time.

The section of his Paper on the "Silt Fallacy" should provoke much thought in foundry circles, and, while I agree that no increase in silt results from efficient milling or from good moulding practice, it is difficult to see how moulding sand in ordinary use can actually lose silt.

My own experience of the matter is that dressing-shop sand is high in silt, and where this sand is used for the making of facing sand, silt extraction or control is a valuable part of the process. A central sand plant has been in operation in the writer's foundry for eight months, and the silt removed up to the present time is 20 tons 18 cwts., 80 per cent, of which is under 100 mesh I.M.M., and it is interesting to note that it contains less than 2 per cent. of clay bond.

While several enthusiasts have produced remarkable results, as, for instance, the 50 per cent. saving in sand costs to which Mr. Hudson refers, the average foundryman should not attempt to copy blindly the practice outlined in these Papers on sand testing. Their decisions should be made on the results of their own tests, as Mr. Hudson points out.—Yours, etc.,

Wm. Y. Buchanan,
Foundry Manager.
John Lang & Sons, Limited,
Near Glasgow.
April 29, 1935.

Contracts Open

Yeovil, May 13.—Supply of 3-in. and 2-in. cast-iron pipes and specials, for the Town Council. Mr. A. J. Price, water engineer, Municipal Offices, Yeovil.

South Australia, May 30.—Water turbines and electric generating and operating machinery (Mount Bold Reservoir Dam), for the South Australian Water Supply Department. The Department of Overseas Trade. (Reference A.Y. 13,019.)

Sutton, May 16.—Supply and erection of four electrically-driven vertical centrifugal pumps, with cast-iron piping, valves and incidental works, for the Sutton and Cheam Town Council. Mr. N. H. Michell, borough engineer and surveyor. (Fee £2, returnable.)

New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Walter Macfarlane & Company, Limited, Saracen Foundry, Possilpark, Glasgow.—Ironfounders. Capital, £100,000. Subscribers: Walter Macfarlane and Alexander Cross.

The Sandvik Steelworks, in their annual statement, report an increase in net profits from 1,040,000 kronor (£57,269) in 1933 to 2,710,000 kr. (£149,229) in 1934. The board proposes to raise the dividend from 6 per cent. to 8 per cent. and to transfer 1.53 millions (£84,251) to reserve, etc. Total sales during 1934 were 31,900,000 kr. (£1,756,608) against 25,000,000 kr. (£1,376,652) during 1933.

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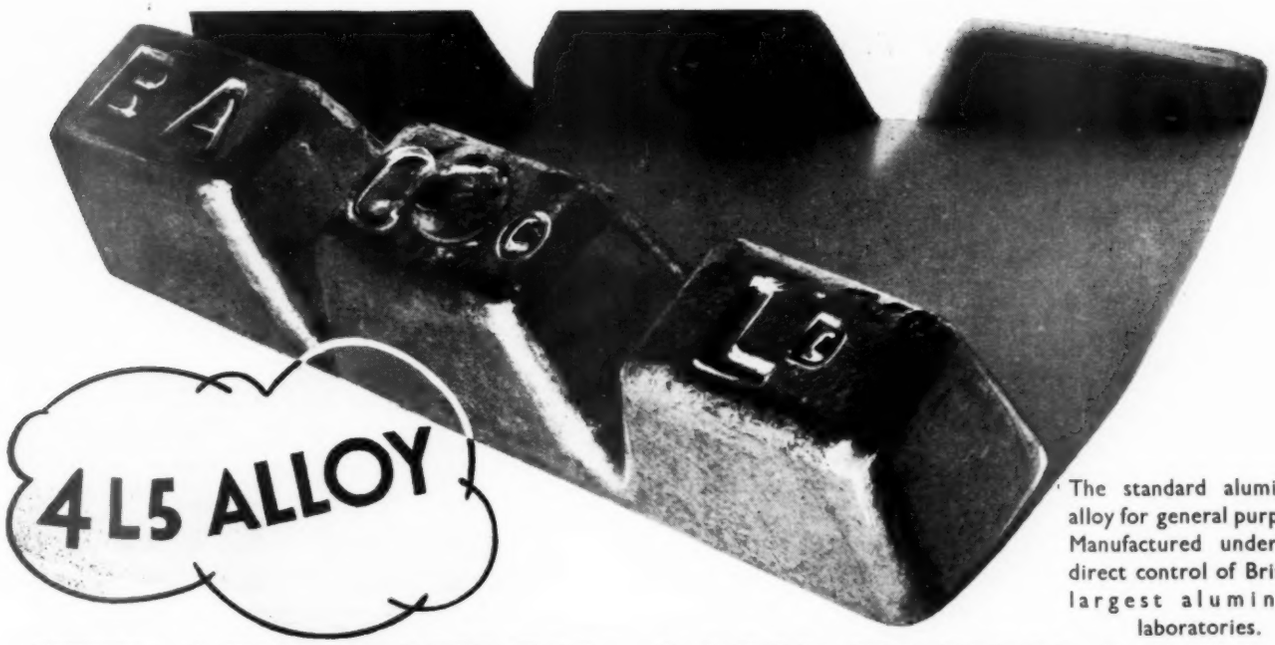

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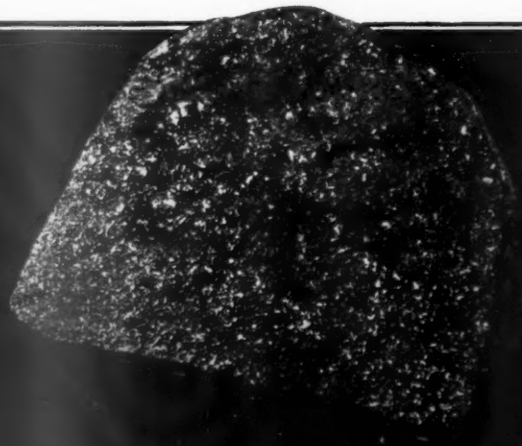

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PIG IRON

Raw Material Markets

In the raw materials markets the event of the week has been the agreement reached by the British and Continental steel industries whereby, for a period of three months, imports not exceeding 643,000 tons of steel per annum will be admitted from the Continent. During this period negotiations for a long-term agreement will be actively pursued. The British industry has undertaken to request the Government to suspend for a period of three months the operation of the increased duties which came into effect on March 26 last, and it is expected that the Government will accept the suggestion. The agreement mainly concerns the steel industries, and will have no effect on the pig-iron section. It is to be welcomed as ensuring to the British manufacturers a protected home market, while removing the risk of greatly intensified competition of an uneconomic character in the export markets.

Pig-Iron

MIDDLESBROUGH.—Recently only two of the 25 blast furnaces operating in this area have been making foundry grade, and there is thus no question of surplus supplies. Although export business is still very restricted, plentiful orders and inquiries have been forthcoming from the home market, and increased production may have to be resorted to. Quotations to home consumers are regulated by the fixed minimum scale.

Although there is still quite a strong demand for East Coast hematite, conditions vary at the furnaces still in commission. Some makers are heavily sold, whilst others are seeking new business. A few foreign orders have been booked recently. Export prices of East Coast hematite are in the region of 63s. 6d. per ton, f.o.b., but for home consumption the minimum figure for No. 1 grade is 69s. per ton delivered Middlesbrough. Delivered prices in other areas are:—North-East Coast, 71s.; Scotland, 75s.; Lancashire, 76s.; Yorkshire, 75s. to 78s.; Birmingham, 79s. per ton.

LANCASHIRE.—Deliveries of pig-iron to Lancashire foundries have now been practically fully resumed. Conditions vary in the various iron-consuming trades, but are generally satisfactory. Foundry-iron quotations are maintained, with current offers of Staffordshire, Derbyshire and Lancashire brands of No. 3 iron for delivery in the Lancashire area on the basis of 74s. per ton, Northamptonshire being quoted at 72s. 6d., Scottish foundry at about 82s. 6d., East Coast hematite at from 75s. to 76s., and West Coast at around 78s. 6d.

MIDLANDS.—Generally speaking, the demand for foundry iron from consumers in this area is quite good. An exception has still to be made, however, in the case of the light-castings manufacturers, some of the largest of whom are still awaiting the arrival of the customary Spring orders. There have been no alterations in prices, the controlled figures delivered Birmingham and Black Country stations for Midland irons being 67s. 6d. for Northants No. 3 and 71s. for Derbyshire, Lincolnshire and North Staffordshire No. 3, subject to a small rebate to large consumers. Irons in the medium-phosphorus category are quoted at between 72s. and 80s., low-phosphorus 85s. to 87s. 6d., Scottish at 85s., and refined iron from £5 7s. 6d. to £7 per ton, delivered Midland stations.

SCOTLAND.—Foundry iron remains the quietest section of the Glasgow pig-iron market, partly owing to the rather quiet conditions at the smaller foundries. Scottish No. 3 foundry remains at 70s. f.o.t. furnaces, with 2s. 6d. extra for No. 1. Regular deliveries of English iron continue to be made to the Falkirk district. Prices of Cleveland iron are unchanged at 67s. 3d. f.o.t. Falkirk and 70s. 3d. f.o.t. Glasgow and district, other English irons being 1s. 3d. per ton below these figures.

Coke

Trade in foundry coke has been rather slack lately, as consumers whose contracts have just relapsed are not renewing, in the hope of securing better terms during the summer months. So far, however, quotations are unchanged, and for delivery in the Birmingham area remain as follow:—Best Durham coke, 36s. to 40s.; Welsh, 34s. to 43s. 6d. per ton.

Steel

The lull in business which made itself felt before Easter has continued since the holidays. For the most part, consumers have confined their purchases to immediate requirements. In the semi-finished steel department, many consumers are carrying heavy stocks and have shown comparatively little interest in the market. In other cases users have been able to satisfy their requirements by specifying against contracts placed some time ago. As a result of these conditions, new business has been quiet. The demand for finished steel has been rather more active. Inquiry upon export account has increased in volume lately and a fair proportion has resulted in business. The home market, however, provides an outlet for the greater part of the production. Most of the works have good orders in hand and heavy deliveries are being made to the consuming trades.

Scrap

Activity in the scrap-iron markets was quickly resumed after the holidays. In the Cleveland district, good machinery cast iron is in moderate demand at 55s. per ton, and 53s. has been paid for foundry cast-iron scrap. In the Midlands, heavy machinery metal remains at 55s., good heavy pipe and plate scrap at 50s. and clean light scrap at 47s. 6d., all delivered works. Reports from South Wales indicate that there is only a quiet local demand for heavy cast iron at 50s. to 52s. 6d., and for cast-iron machinery scrap at 52s. 6d. to 55s. In Scotland, there is a good market for good machinery cast-iron scrap, suitable for foundry use, at 56s. 6d., and for ordinary cast-iron foundry scrap to the same specification at 51s. 6d.

Metals

Copper.—The standard copper market has a rather stronger tone, although dealing has not been very active. Industrial purchasing has been of a rather limited nature, although it is believed that there has been no falling off in consumption. The international agreement for the restriction of copper output comes into force as from yesterday, May 1.

Daily quotations:—

Cash.—Thursday, £31 to £31 1s. 3d.; Friday, £31 6s. 3d. to £31 8s. 9d.; Monday, £31 2s. 6d. to £31 3s. 9d.; Tuesday, £31 7s. 6d. to £31 10s.; Wednesday, £32 3s. 9d. to £32 5s.

Three Months.—Thursday, £31 8s. 9d. to £31 10s.; Friday, £31 15s. to £31 16s. 3d.; Monday, £31 10s. to £31 11s. 3d.; Tuesday, £31 16s. 3d. to £31 17s. 6d.; Wednesday, £32 12s. 6d. to £32 13s. 9d.

Tin.—The market has been rather dull during the past week, but took on a decidedly firmer aspect yesterday (Wednesday). A certain amount of Continental buying is reported for the purposes of armament manufacture.

The April Bulletin of the International Tin Research and Development Council shows that world consumption of tin in manufacture for the year ended February 28, 1935, amounted to 130,200 tons, compared with 137,300 tons for the previous year. Consumption during February, 1935, was 10,063 tons, compared with 9,751 tons in the previous month and with 9,146 tons in February, 1934. Consumption in the United States in February, 1935, was 4,071 tons, against 3,024 tons in February, 1934; and in the United Kingdom 1,846 tons against 1,979 tons. In the first two months of 1935 the approximate world consumption of tin in tinplate was 8,300 tons, compared with 6,700 tons in the corresponding period of 1934.

Market fluctuations:—

Cash.—Thursday, £224 15s. to £225; Friday, £224 10s. to £224 15s.; Monday, £223 to £223 5s.; Tuesday, £224 15s. to £224 17s. 6d.; Wednesday, £226 to £227.

Three Months.—Thursday, £220 10s. to £220 15s.; Friday, £220 7s. 6d. to £220 10s.; Monday, £218 5s. to £218 10s.; Tuesday, £219 10s. to £219 15s.; Wednesday, £221 to £221 5s.

Spelter.—Although the galvanising trade is still very much "under the weather," the aggregate consumption of spelter in this country is well maintained, owing to the activity at the zinc-rolling mills and in the brass and battery trades.

There have been rumours of conversations between producers with a view to resuscitating the Zinc Cartel. It is unlikely, however, that any move in this direction will be made until the present English duty on foreign imports is either removed or remodelled. A further obstacle is that the German producers, with the encouragement of their Government, have recently doubled their output.

Official quotations:—

Ordinary.—Thursday, £13; Friday, £13 5s.; Monday, £13 2s. 6d.; Tuesday, £13 8s. 9d.; Wednesday, £13 17s. 6d.

Lead.—The future of the import duty remains uncertain, and buying has been on a restricted scale. This inactivity should only be temporary, however, as the lead-consuming trades are generally experiencing a period of activity.

Day-to-day prices:—

Soft Foreign (Prompt).—Thursday, £12 5s.; Friday, £12 8s. 9d.; Monday, £12 12s. 6d.; Tuesday, £13 2s. 6d.; Wednesday, £13 5s.

Henry Wiggin & Company, Limited

(*Concluded from page* 294.)

of the business was very rapid and great strides were made. In this period there were laid down several new wire mills, improved types of annealing furnaces, and draw benches for the production of profiles and sections. The Wiggin rolling mills at this time also took part in pioneer work relating to Duralumin, which was to become such an important development in the light-alloy field. Some of the first high-class precision rolling mills in this country were also laid down by Henry Wiggin & Company, Limited, during this same period.

Post-War Changes

After the war the supplies of raw material became uncertain and competition in the nickel market grew stronger, due to the growth of The Mond Nickel Company and to large imports of American nickel. Conversations between the Mond Nickel Company, Limited, and Henry Wiggin & Company, Limited, took place, and the two subsequently became associated.

Recent Developments

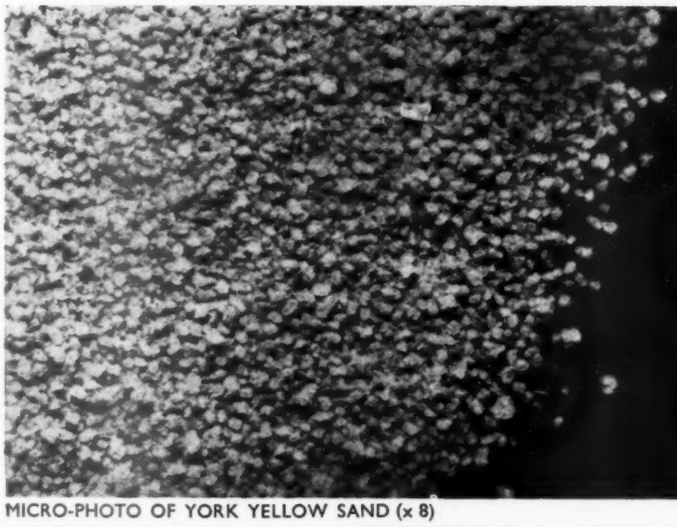
This association has been remarkably successful, and Wiggin Street has now one of the best-equipped nickel-alloy mills in Europe and probably the world. A great variety of work is undertaken in connection with the production of finished and semi-finished manufactures in nickel and its alloys, of which the production of nickel anodes, electrical-resistance alloys and spoon and fork blanks are amongst the most important. The resistance materials manufactured are the well-known nickel-chromium alloy Brightray, the nickel-chromium-iron alloy Glowray, the nickel-iron alloy Dullray and the copper-nickel alloy Ferry.

Much of the company's success may be traced to the care with which these materials are tested before they are sent out and to the fact that a technical service department is maintained to give information and advice free of any obligation. This service relates not only to information concerning electrical-resistance alloys but to all the other products of the company, pure nickel, Monel Metal, nickel silver, nickel-iron alloys and nickel anodes. In no period of its existence has the progressive spirit of the company been so much to the fore as in the last few years, during which time nearly every department has been reorganised and a great deal of new plant laid down.

On behalf of the foundry industry we offer to Henry Wiggin & Company, Limited, very sincere congratulations on attaining their centenary. The passage of time and scientific discovery have brought community of interest undreamt of by the originators of the business.

XUM

Moulders who want a sand with that little extra resistance for casting iron and iron alloys at high temperature, and which will produce a good skin on the casting, will find no better medium than York Yellow Sand. It is well bonded, fine in grain, yet permeable and highly refractory.



YORK YELLOW

MICRO-PHOTO OF YORK YELLOW SAND (x 8)

GENERAL REFRACTORIES LIMITED.

Telephones: Sheffield 22311 (5 lines). London 7361 Temple Bar.

Head Office: Genefax House, Sheffield.

London Office: Russell House, Adelphi, W.C.2.

Telegrams: Genefax, Sheffield. Genefax, Rand, London.

RAW MATERIALS—PRICE LIST

(Wednesday, May 1, 1935)

COPPER

	£	s.	d.
Standard cash	32	3	9
Three months	32	12	6
Electrolytic	35	10	0
Tough	34	5	0
Best selected	34	15	0
Sheets	60	0	0
India	46	5	0
Wire bars	36	5	0
Ingot bars	36	5	0
H.C. wire rods	39	0	0
Off. av. cash, April	31	5	4⅞
Do., 3 mths., April	31	13	9
Do., Sttlmnt., April	31	5	3
Do., Electro, April	35	1	10½
Do., B.S., April	34	13	0⅜
Do., wire bars, April	35	8	6
Solid drawn tubes			9¾d.
Brazed tubes			9¾d.
Wire			6¼d

BRASS

Solid drawn tubes	9d.
Brazed tubes	11d.
Rods, drawn	8¾d.
Rods, extd. or rlld.	4½d.
Sheets to 10 w.g.	7½d.
Wire	7⅜d.
Rolled metal	7d.
Yellow metal rods	4½d.
Do. 4 × 4 Squares	5½d.
Do. 4 × 3 Sheets	5½d.

TIN

	£	s.	d.
Standard cash	226	0	0
Three months	221	0	0
English	226	5	0
Bars	228	2	6
Straits	234	10	0
Australian (nom.)		—	
Eastern	231	2	6
Banca	234	0	0
Off. av. cash, April	223	13	8½
Do., 3 mths., April	219	18	0¾
Do., Sttlmt., April	223	13	9

SPELTER

	£	s.	d.
Ordinary	13	17	6
Remelted	14	5	0
Hard	11	10	0
Electro 99.9	16	10	0
English	15	2	6
India	13	5	0
Zinc dust	17	5	0
Zinc ashes	3	0	0
Off. aver., April	13	0	2¼
Aver. spot, April	12	17	9¾

LEAD

	£	s.	d.
Soft foreign ppt.	13	5	0
Empire (nom.)	14	7	6
English	15	5	0
Off. average, April	12	6	10⅞
Average spot, April	12	4	7½

ALUMINIUM

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	22	15	0
Do., V.M. ex-whse.	23	2	6
Rods	27	15	0

ANTIMONY

	£	s.	d.		£	s.	d.
English	76	0	0	to	79	0	0
Chinese, ex-whse., (nom.)					65	0	0
Crude						—	

QUICKSILVER

	£	s.	d.		£	s.	d.
Quicksilver	11	7	6	to	11	17	6

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	£8 17 6
45/50%	£12 15 0
75%	£17 17 6
Ferro-vanadium—	
35/50	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£15 15 0
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	£31 10 0
4/6% car.	£21 15 0
6/8% car.	£21 10 0
8/10% car.	£21 10 0
Ferro-chrome—	
Max. 2% car.	£34 0 0
Max. 1% car.	£36 5 0
Max. 0.70% car.	£37 5 0
70%, carbon-free	9¾d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	5/- to 5/6 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to £11 5 0
76/80% packed	£11 15 0 to £12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d
Finished bars, 18% tungsten	2s. 9d

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 7/32 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.		£	s.	d.
South Wales—							
Heavy steel	2	15	0	to	2	16	0
Bundled shrngs.					2	7	6
Mixed iron and steel	2	10	0	to	2	11	0
Heavy cast iron	2	10	0	to	2	12	6
Good machinery	2	12	6	to	2	15	0
Cleveland—							
Heavy steel					2	12	6
Steel turnings					1	15	0
Cast-iron borings					1	5	0
Heavy cast iron					2	13	0
Heavy machinery					2	15	0
Midlands—							
Light cast-iron scrap					2	7	6
Heavy wrought iron	2	17	6	to	3	0	0
Steel turnings, f.o.r.					1	14	0
Scotland—							
Heavy steel					2	10	0
Ordinary cast iron					2	11	6
Engineers' turnings					1	19	0
Cast-iron borings	1	17	6	to	1	18	9
Wr'ght-iron piling	2	15	0	to	2	17	6
Heavy machinery					2	16	6

London—Merchants' buying prices, delivered yard.

	£	s.	d.		£	s.	d.
Copper (clean)					27	0	0
Brass					18	0	0
Lead (less usual draft)					11	0	0
Tea lead					7	15	0
Zinc					9	0	0
New aluminium cuttings					66	0	0
Braziery copper					23	0	0
Gunmetal					25	0	0
Hollow pewter					155	0	0
Shaped black pewter					110	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	70/-
Foundry No. 3	67/6
,, at Falkirk	67/3
,, at Glasgow	70/3
Foundry No. 4	66/6
Forge No. 4	66/6
Hematite No. 1	69/-
Hematite M/Nos.	68/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	72/6
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	67/-
,, No. 3 fdry.	71/-
Northants forge	63/6
,, fdry. No. 3	67/6
,, fdry. No. 1	70/6
Derbyshire forge	67/-
,, fdry. No. 3	71/-
,, fdry. No. 1	74/-
Scotland—	
Foundry No. 1, f.o.t.	72/6
,, No. 3, f.o.t.	70/-
Hem. M/Nos. d/d	71/-
Sheffield (d/d district)—	
Derby forge	64/6
,, fdry. No. 3	68/6
Lincs forge	64/6
,, fdry. No. 3	68/6
E.C. hematite	81/6
W.C. hematite	83/6
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	74/-
Staffs fdry. No. 3	74/-
Northants fdry. No. 3	72/6
Cleveland fdry. No. 3	74/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	82/6
Clyde, No. 3	82/6
Monkland, No. 3	82/6
Summerlee, No. 3	82/6
Eglinton, No. 3	82/6
Gartsherrie, No. 3	82/6
Shotts, No. 3	82/6

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

	£	s.	d.		£	s.	d.
Iron—							
Bars (cr.)	9	12	6	to	9	15	0
Nut and bolt iron	7	10	0	to	8	0	0
Hoops	£10 10 0 and up.						
Marked bars (Staffs) f.o.t.	12	0	0				
Gas strip	10	10	0	and up.			
Bolts and nuts, ¾ in. × 4 in.	14	2	6	and up.			
Steel—							
Plates, ship, etc.	8	15	0	to	8	17	6
Boiler plts.	9	5	0	to	9	7	6
Chequer plts.					10	7	6
Angles					8	7	6
Tees					9	7	6
Joists					8	15	0
Rounds and squares, 3 in. to 5½ in.					9	7	6
Rounds under 3 in. to ⅝ in. (Untested)					8	12	0
Flats—8 in. wide and over					8	12	6
,, under 8 in. and over 5 in.					8	17	6
Rails, heavy	8	5	0	to	8	10	0
Fishplates	12	5	0	to	12	10	0
Hoops (Staffs)					9	7	0
Black sheets, 24g. (4-t. lots)					10	10	0
Galv. cor. shts. (,,)					13	0	0
Galv. flat shts. (,,)					13	10	0
Galv. fencing wire, 8g. plain					14	10	0
Billets, soft	5	10	0	and up.			
Billets, hard	6	17	6	to	7	2	6
Sheet bars	5	0	0	to	5	7	6
Tin bars	5	2	6	to	5	7	6

PHOSPHOR BRONZE

	Per lb. basis.
Strip	9¾d.
Sheet to 10 w.g.	10¾d.
Wire	11¾d.
Rods	10¾d.
Tubes	13½d.
Castings	12d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7¼
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	20.26
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic, Valley	18.00
Bessemer	20.76
Malleable, Valley	18.50
Grey forge, Valley	18.00
Ferro-mang. 80%, seaboard	85.00
O.-h. rails, h'y, at mill	36.37½
Billets	27.00
Sheet bars	28.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.70
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.60
Plain wire	2.30
Barbed wire, galv.	3.00
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 30/-
,, furnace	19/- to 20/-
Durham foundry	19/- to 22/-
,, furnace	16/6 to 17/9
Midlands, foundry	—
,, furnace	—

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	18/2 to 19/2
,,	28×20 ,,	36/4 to 38/4
,,	20×10 ,,	26/- to 26/3
,,	18¾×14 ,,	18/6 to 18/9
C.W.	20×14 ,,	15/6 to 16/6
,,	28×20 ,,	33/- to 33/6
,,	20×10 ,,	23/- to 24/-
,,	18⅜×14 ,,	16/- to 17/-

SWEDISH CHARCOAL IRON & STEEL

	£	s.	d.		£	s.	d.
Pig-iron	£6	0	0	to	£7	0	0
Bars-hammered, basis	£16	0	0	to	£16	10	0
Bars and nail-rods, rolled, basis	£15	15	0	to	£16	0	0
Blooms	£10	0	0	to	£12	0	0
Keg steel	£30	0	0	to	£31	0	0
Faggot steel	£18	0	0	to	£23	0	0
Bars and rods dead soft, st'l	£10	0	0	to	£12	0	0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£	s.	d.		
Apr. 25 ..	31	0	0	dec.	2/6
,, 26 ..	31	6	3	inc.	6/3
,, 29 ..	31	2	6	dec.	3/9
,, 30 ..	31	7	6	inc.	5/-
May 1 ..	32	3	9	,,	16/3

Electrolytic Copper

	£	s.	d.		
Apr. 25 ..	34	15	0	No	change
,, 26 ..	34	15	0	,,	,,
,, 29 ..	34	15	0	,,	,,
,, 30 ..	34	15	0	,,	,,
May 1 ..	35	10	0	inc.	15/-

Standard Tin (cash)

	£	s.	d.		
Apr. 25 ..	224	15	0	dec.	20/-
,, 26 ..	224	10	0	,,	5/-
,, 29 ..	223	0	0	,,	30/-
,, 30 ..	224	15	0	inc.	35/-
May 1 ..	226	0	0	,,	25/-

Tin (English ingots)

	£	s.	d.		
Apr. 25 ..	225	5	0	dec.	15/-
,, 26 ..	224	15	0	,,	10/-
,, 29 ..	223	10	0	,,	25/-
,, 30 ..	225	0	0	inc.	30/-
May 1 ..	226	5	0	,,	25/-

Spelter (ordinary)

	£	s.	d.		
Apr. 25 ..	13	0	0	dec.	1/3
,, 26 ..	13	5	0	inc.	5/-
,, 29 ..	13	2	6	dec.	2/6
,, 30 ..	13	8	9	inc.	6/3
May 1 ..	13	17	6	,,	8/9

Spelter (Electro, 99.9 per cent.)

	£	s.	d.		
Apr. 25 ..	15	12	6	dec.	1/3
,, 26 ..	15	16	3	inc.	3/9
,, 29 ..	15	13	9	dec.	2/6
,, 30 ..	16	0	0	inc.	6/3
May 1 ..	16	10	0	,,	10/-

Zinc Sheets (English)

	£	s.	d.		
Apr. 25 ..	22	10	0	No	change
,, 26 ..	22	10	0	,,	,,
,, 29 ..	22	10	0	,,	,,
,, 30 ..	22	15	0	inc.	5/-
May 1 ..	22	15	0	No	change

Lead (English)

	£	s.	d.		
Apr. 25 ..	14	5	0	No	change
,, 26 ..	14	10	0	inc.	5/-
,, 29 ..	14	10	0	No	change
,, 30 ..	15	0	0	inc.	10/-
May 1 ..	15	5	0	,,	5/-

A COMPARISON OF SCRAP PRICES

Prices of Heavy Steel Scrap (Delivered) in the Principal Districts at the Beginning of Each Month in the Years 1929–1934.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Scotland—													
1929	3 5 6	3 7 6	3 12 6	3 15 0	3 15 0	3 15 0	3 15 6	3 16 0	3 17 6	3 15 0	3 12 6	3 10 6	3 13 1½
1930	3 9 0	3 7 6	3 5 0	3 5 0	3 0 6	2 15 0	2 12 0	2 10 0	2 13 3	2 10 0	2 10 0	2 10 0	2 17 3½
1931	2 7 6	2 7 6	2 5 0	2 5 0	2 0 0	1 17 6	1 17 6	1 17 6	1 17 6	1 15 0	2 0 0	2 2 6	2 1 0½
1932	2 2 6	2 2 6	2 0 0	1 17 6	1 17 6	1 17 6	1 15 0	1 15 0	1 12 6	1 13 0	1 12 6	1 15 0	1 16 9½
1933	1 15 0	1 17 6	1 18 6	1 18 9	1 18 0	1 17 6	1 18 9	2 0 0	2 2 6	2 5 0	2 7 6	2 8 9	2 0 7½
1934	2 8 9	2 14 3	2 13 0	2 13 0	2 12 0	2 10 0	2 10 6	2 10 6	2 11 0	2 10 9	2 10 0	2 10 0	2 11 2
1935	2 10 0	2 10 0	2 10 0	2 10 0	—	—	—	—	—	—	—	—	—
North-East Coast—													
1929	3 0 0	3 2 6	3 3 6	3 3 6	3 3 6	3 5 0	3 5 0	3 5 0	3 5 0	3 6 6	3 5 0	3 3 6	3 4 0
1930	3 3 6	3 3 6	3 2 0	3 0 0	2 17 6	2 10 0	2 10 0	2 7 6	2 7 6	2 7 6	2 5 0	2 6 0	2 13 4
1931	2 6 0	2 6 0	2 5 0	2 5 0	2 2 6	2 0 0	1 17 6	1 17 6	1 17 6	1 17 6	1 17 6	2 2 6	2 1 2½
1932	2 0 0	2 0 0	1 15 0	1 15 0	1 15 0	1 15 0	1 15 0	1 15 0	1 15 0	1 12 6	1 15 0	1 17 6	1 15 10
1933	2 0 0	2 0 0	2 5 0	2 0 0	1 15 0	1 17 6	2 2 6	2 2 6	2 3 6	2 5 0	2 7 6	2 7 6	2 2 2
1934	2 10 0	2 16 0	2 10 0	2 7 6	2 7 6	2 10 0	2 9 9	2 10 0	2 10 0	2 10 0	2 11 6	2 11 3	2 10 3½
1935	2 11 6	2 11 9	2 12 0	2 12 0	—	—	—	—	—	—	—	—	—
South Wales—													
1929	3 8 6	3 10 6	3 15 0	4 0 0	4 0 0	3 18 0	3 17 6	3 17 6	3 15 0	3 15 0	3 12 6	3 7 6	3 14 9
1930	3 7 6	3 6 0	3 6 0	3 4 0	3 2 6	2 17 6	2 16 0	2 15 0	2 14 9	2 12 6	2 12 6	2 5 0	2 18 3½
1931	2 5 0	2 7 6	2 7 6	2 7 6	2 5 0	2 2 6	2 0 0	2 0 0	1 18 0	2 2 6	2 5 0	2 7 6	2 4 0
1932	2 6 6	2 6 0	2 5 0	2 2 6	2 2 0	1 19 0	1 17 6	1 18 6	1 18 0	1 18 0	1 17 6	1 18 0	2 0 8½
1933	2 0 0	2 1 6	2 4 0	2 3 6	2 3 6	2 3 0	2 5 0	2 5 0	2 8 0	2 10 0	2 10 0	2 10 0	2 5 3½
1934	2 10 0	2 16 3	2 15 9	2 13 9	2 14 3	2 15 0	2 14 3	2 14 3	2 15 0	2 15 6	2 15 6	2 15 6	2 14 7
1935	2 15 6	2 15 6	2 15 6	2 15 6	—	—	—	—	—	—	—	—	—

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.

13, RUMFORD STREET, LIVERPOOL.

PIG

IRON

All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2.

ZETLAND ROAD, MIDDLESBROUGH.

Notice

Small Advertisements in this section of the Journal are accepted at the prepaid rate of 6d. per line, first line in capitals counting two, average 6 words per line. Minimum charge for one insertion 3/-

(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

CHEMIST wanted for blast furnaces and ironfoundries.—Apply, stating qualifications, experience and age. — Address, "CHEMIST," WM. PORTEOUS & COMPANY, Advertising Agents, Glasgow.

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Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

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